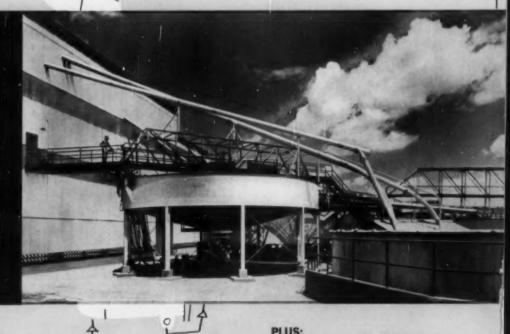
**APRIL 1958** CHEMICAL ENGINEERING PROGRESS

what's going on in hydrometallurgy

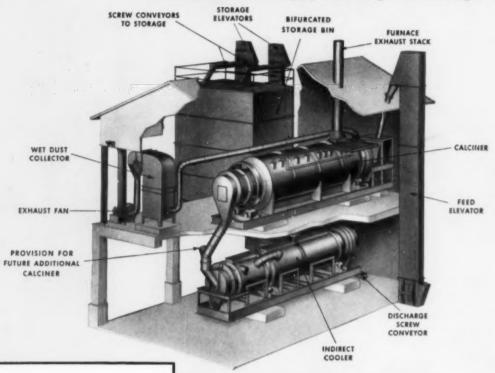


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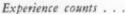
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Published monthly by American Institute of Chemical Engineers at 47-36 36th Street, Long Island City 1, New York. Editorial and Advertising Offices. 25 West 45th Street, New York 26, N. Y. Communications should be sent to the Editor. Statements and opinions in Chemical Engineers assumes no responsibility for them. Subscriptions: U. S. and possessions, one year 36.00; two years 310.00 (Applies to U. S. and possessions only). Canada, 86.59; Pan American Union, 37.50; Other Foreign, \$8.00. Single copies of Chemical Engineering Progress older than one year coat \$1.00 a copy: others are 75 cents. Second class mailing privileges authorized at New York, New York. Copyright 1958 by American Institute of Chemical Engineeria Indexe of Circulations. Chemical Engineering Progress is indexed regularly by Engineering Index, Inc.

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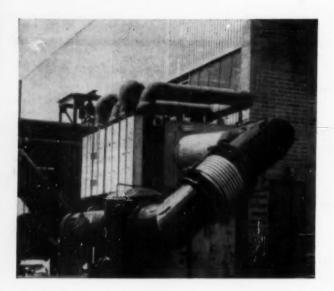
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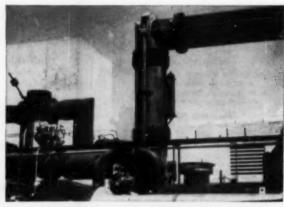
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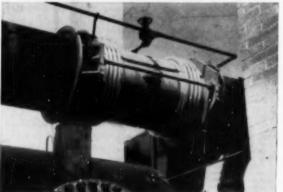
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These photographs show installations of special ADSCO Corruflex Expansion Joints at the Fairchild Engine Division, Fairchild Engine & Airplane Corp., Deer Park, Long Island, N. Y. All joints are designed to absorb lateral motion only, except that the long universal joint, right center, also absorbs any axial growth of its own. All joints are equipped with internal sleeves to smooth out the flow of high-temperature air being carried by the piping systems. They are not standard joints; they are specially engineered, specially manufactured.

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#### MEASUREMENT in the U.S.S.R.

#### Allen V. Astin, Director National Bureau of Standards

Soviet leaders have repeatedly emphasized that their major competitive objective is to overtake and excel the capitalistic nations in production per capita. The Russians' announced intention to compete in this area should be of immediate interest to all American industrial leaders because, if we are successful in our efforts to maintain world peace, we shall most certainly continue to be confronted by their challenge in terms of industrial productivity. Although we now excel the Russians substantially in our production of consumer goods, we should not be lulled into believing that their technological base is not capable of being developed for such production if their leaders should so decree. The fact that they have surprised us, first with their ability to build an A bomb and then an H bomb more quickly than we had expected and, more recently, to launch the first earth satellite, should be ample warning that the technological foundation from which these achievements evolved is a very substantial one. Much attention has atready been directed to one element ot this foundation: namely, their extensive program for training scientists and engineers. I should like to draw attention to another important element of that foundation: namely, their extensive program in the techniques ot physical measurement.

Most of the information I have on this subject comes from the Russian journal MEASUREMENT ENGINEERING. the official organ of the Committee on Standards, Measures, and Measure-ment Apparatus of the Council of Ministers of the U.S.S.R. Articles in this journal point out that the major objective of the 6th Five-year Plan, which began in 1956, is to increase their means of production by approximately 70% and their output of consumer goods by approximately 60%. During this period there are expected to be substantial increases in the output of basic materials and an increase in the output of their machine tool industry by approximately 80%. Fundamental to these increases in productivity, the Plan calls for extensive expansion of their instrumentation industry. All types of electrical, mechanical, optical, radiation measuring instruments, and related instruments for automation will be increased by substantial amounts, averaging 3½ times. Concurrent with the scheduled increases in quantity, there is a substantial effort to improve the quality of their measuring instruments and techniques.

A further objective of their current program is a large-scale plan for the broad adoption throughout industry of automatic control and regulation of technological processes in order "to allow the release of a considerable quantity of qualified labor, raising the precision of products or of the work of machines and mechanisms and improving the quality of production." Here the plan points out that their automation program is linked to the need for precise adjustments of control mechanisms and to the precise measurement of essential parameters in the production process. This in turn is related to a nation-wide program for assuring uniformity and accuracy of their means and methods of measurement

The entire program of instrument development and production, as well as the means of utilizing their new instruments effectively, is under the Committee on Standards, Measures and Measurement Apparatus of the Council of Ministers of the U.S.S.R. Five research institutions work directly for this Committee on new and improved techniques for physical measurement and on the development and maintenance of the basic standards for measurement. Operating under the supervision of the institutes is a network of calibration centers. Their Plan calls for 129 such centers by 1960. A major function of these calibration centers is to evaluate and approve all of the measuring instruments used in any Russian production plant. One of the available reports includes an item chastizing industry for not measuring up to new precision standards and urging that greater authority be lodged in the regional calibration centers so that they will not only pass on the precision characteristics of the instruments but also upon the way they are used in industrial plants. Another function of the calibration centers is to make available to industry the latest advances in new

measurement techniques coming from the research institutes. This is indeed a substantial chain to insure not only that new measurement techniques are developed and made available but also that they are used effectively.

One series of papers reporting on the results of a Standards and Measurement Conference held in March, 1956, reveals that a sizable and high-order technical investment is being made in these areas. The conference dealt principally with standards and measurements as they applied to the machine production industry. More than 500 delegates, including research personnel, were in attendance. The conference, lasting 4 days, took up some of the most advanced problems in measurement research...

The reports also indicate a practical approach to the efficient utilization of varying degrees of precision. Most meteorologists are familiar with all too many instances where extreme tolerances have been imposed unnecessarily with resulting cost increases and inefficiencies. This usually comes from a lack of appreciation of measurement problems by specifications writers. The Russians, through a systematic method of classification and application of varying degrees of precision in their instruments and their use, coupled with thorough education and training, seem to have this problem well in hand.

A description of their exhibits at the Standards and Measurement Conference reveals appreciable informa-tion on the level of their measurement competence. A particularly interesting area is that dealing with their objectives and current competence in the calibration of temperature measuring devices. In 1956 they claimed to be prepared to make calibrations of temperature measuring devices up to 6000°C., and their Five-year Plan calls for extending this competence to 14,000°C. by 1960. At the National Bureau of Standards we have reasonably satisfactory means for providing temperature calibrations only to 2800° C. We have on occasion extended such calibration to 4200°C. by impromptu means, but our capability for this and higher temperatures is severely restricted by lack of means for producing high temperatures, since continued on page 10

From a talk given before the Washington Rubber Group, Washington, D. C., February 18, 1958.

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ACE PARIAN	Threaded Pipe 1/2 to 2"	Odorless, tasteless, rigid polyethylene, best for sub-zero uses. Best resistance of any plastic at room temp. except to acetic acid.	Diaphragm valves with Parian body, 1/2 to 2"	351	
ACE HARD RUBBER	Threaded ½ to 4" Flanged 1½ to 8"	1/2 to 4" to alkalis, inorganic acids, many organics, Flanged all salts. Ideal for chlorine, fluorine. Wid-		CE-51	
ACE SARAN	Pipe 1/2 to 4" Tubing			CE-38	
ACE- FLEX	Flexible Tubing 1/5 to 11/4"	General-purpose transparent flexible tub- ing. Non-toxic, odorless, tasteless. Can steam sterilize. Excellent for chemicals.	Ace hard rubber plug valves, bibb cocks, etc.	66	
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SEE ACE EQUIPMENT IN CHEMICAL ENGINEERING CATALOG our best high temperature-producing device is a small solar furnace capable of attaining temperatures of about 3500°C. The Russians' interest and competence in making measurements at such high temperatures is indicative, I believe, of a very substantial effort by them in development activities on this very important technological frontier, which is relevant to such things as high energy fuels and heat exchangers for thermonuclear and atomic energy converters.

Although our knowledge of some of these Russian activities is still somewhat sketchy, it is possible to draw certain inferences: 1. The program for standards and precision measurement is apparently operated from a higher governmental level than any other industrial activity in the U.S.S.R., 2. The investment in these areas is extremely large and seems to be especially directed toward fulfilling the precision requirement of complex automatic machine production for intended automation of large segments of the U.S.S.R. industry. 3. There appears to be a clear tendency to lean heavily on theoretical analysis of technological problems and in encouraging research and development programs in the instrumentation of precise measurement. 4. There is a program to inculcate cooperative technological efforts among relevant branches of the economy, including the Ministry of Higher Education, to advance precision measurement throughout industry.

These are all matters of serious concern to this nation. Russian achievements in these areas must inevitably have a vital effect upon the American position within the community of nations. In spite of the ever ominous military threat, the challenge in the area of basic industrial productivity has been clearly made by the Russians.

#### Professional Unity

When I look at the multiplicity of engineering organizations, societies, and associations and study the long record of debate among the various engineering and allied societies on how to achieve a "unified professional organization," I fear we in the educational world cannot do much about a problem which the most interested parties, namely the engineers themselves, have not been able to resolve.

Frederick L. Hovde, Pres. Purdue University



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# Should there be a Standard Classification System for Engineering Literature?

In order that comments on the provocative suggestions made by Mr. Swanton in the following letter should appear with the suggestions themselves, we submitted an advanced copy of Mr. Swanton's letter to two interested persons for evaluation. The suggestions and the comments they elicited are printed herewith. Ed.

#### The Proposal

Few will deny that the problem of locating existing information on a specific subject is the most universal problem of engineers and scientists. It is encountered on the one extreme by the solitary engineer with his small personal collection of books and papers and on the other extreme by research workers and patent searchers for the giant corporations and governmental agencies combing the vast store of international technical literature. Yet strangely enough, technical societies have done very little collectively to bring about a simplification of this problem.

Inefficiencies in the retrieval of existing knowledge in all branches and at all levels of technical work result daily in vast economic waste due to lost time, duplication of effort, and less perfect than necessary designs. Because of the tremendous scope of this problem any truly significant reduction in this waste must come as the result of a cooperative effort by the organized branches of technology. These branches have many common fundamentals and applied problems. It is difficult to establish clear-cut boundaries between them and yet to avoid this completely is to promote chaos. Friendly rivalry is worthwhile, but not at the expense of progress.

It is apparent that basic remedies and simplifications will not come from uncoordinated individual effort, from autonomous information and documentation centers, or from basically nontechnical groups such as the Special Libraries Association. Specialists in each area of technology must eventually contribute to the over-all solution.

In the light of these arguments it is proposed that the American Standards Association be asked to sponsor work leading to the development of an American standard classification system for engineering literature.

Why is a subject classification system proposed when some experts feel that the number of possible combinations and permutations of criteria are so great as to render such a task all but hopeless? Because,

1. It is the only way in which both size extremes can benefit.

2. The frequent recurrence of identical permutations of criteria and of facets of technology make possible a much simpler systematic or logical system than has been apparent from previous work such as the Dewey Decimal and Library of Congress Systems. Compare either of these with that by William Bolles. Consider the fact that although materials of construction. for example, may be of interest in many different branches of technology, they need be classified in detail in only one place, and reference can be made when occasion arises. Codes and standards, data, correlations, mathematical treatment, performance testing, operating hazards, and commercial equipment are only a few of the facets common to all branches of technology. Thus, it may be seen that the task is not nearly as hopeless as it may at first

3. A clearly defined code number, or code numbers, assigned by the author or by a technically competent reviewer would be a far more precise and condensed classification for a paper than is possible with subject descriptions, even when encoded for machine searching.

Systematic classification automatically produces or vastly simplifies the preparation of bibliographies.
 Benefits will result from better orientation in technology by all, especially novices and specialists.

It is not advocated that reference material be physically filed by the proposed system although it may be helpful in placing books on shelves and in organizing manuals, handbooks, and project files. Periodical literature and research reports should always be filed horizontally, i.e., on the basis of origin and date. Only in this way will the continuity of journals and the integrity of filed material be preserved

against changes in the system which must inevitably occur from time to

The system would be used rather for card indexes which could be strategically located within an organization to make its information facilities more generally available. Multiple listing on cards, punched or plain, on microfilm or magnetic tape, will reduce the work of searching, or the job of renumbering if occasion demands, by a factor of ten or more.

If the reader agrees with the thesis of this letter that cooperative effort by organized technical societies with respect to this problem is desirable, make your feelings known, for it is quite evident that many responsible leaders of our societies do not appreciate the need as acutely as do those on the firing line.

Walter F. Swanton, Member A. I. Ch. E.

Lynchburg, Va.

#### The Comments

Mr. Swanton's comment puts a burden on the technical societies which certainly has in the past been met, at least in part, at a considerable cost and one not borne by the society members. Examples are Chemical Abstracts which covers chemistry, chemical engineering, extractive metallurgy and much other metallurgy, and a variety of subjects from 7500 journals abstracted regularly. The American Society of Metals does an effective job with Metallurgical Abstracts in some areas not covered by C. A., Ceramics are covered by the American Ceramic Society, textiles by English groups, and other areas are covered by Engineering Index, Industrial Arts Index, and so on. Through these it is possible, in large centers, to retrieve information.

As to a subject classification system and related matters, these have been developed by the hundreds and only a few have had workability. Just a nomenclature and symbol designation job in chemical engineering took years and the American Standards Association abbreviations took years of many organizations before agreement

continued on page 14

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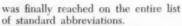
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from page 12



Coordination by handbooks is always going forward. The writer recently completed a five-year job on the "Handbook of Engineering Materials" (McGraw Hill) with help of 153 contributors.

Mr. Swanton's job can be done for him by the technical societies if some way can be found to find the funds. The job is too costly for anyone or any group to carry it on. Not all societies can be as well funded as the ACS and Chemical Abstracts or the A.S.M. (who spent about \$45 per member for the member's \$10 a year dues). Mr. Swanton should come forward with suggestions as to funds and a personal willingness to meet the cost. wonder if he knows the cost of the forthcoming 4th decennial index of Chem. Abstracts and the cost to individual members. It might shock him. CHARLES L. MANTELL, New York, N.Y.

I have noted with interest Mr. Walter Swanton's letter to the editor proposing an improved filing system for engineering data and information.

I think it would be well for the A. I. Ch. E. to make some investigations for itself before taking action on getting the proposal before ASA. Instead of all Technical Societies getting together and petitioning ASA to set up a project, as was suggested by Mr. Swanton, possibly we could have the problem investigated by our Standards Committee, and get its recommendation. Then, if favorable, the Institute could request ASA directly to consider setting up a Sectional Committee to go ahead with the job, which we could offer to sponsor at that time.

This would seem to be a proper project for the Standards Committee to undertake, and after acceptance by ASA all the other societies and associations interested would be called in to appoint their representatives on the Sectional Committee established under the procedures of ASA. I am proceeding to set up a Standards Committee meeting for the Philadelphia meeting, and will include this matter for consideration. In the meantime, I would be happy to hear from any interested parties.

Jas. C. Lawrence,

Chairman, Standards Committee, Moylan, Pa. A. I. Ch. E.

continued on page 16





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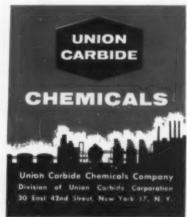
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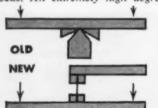


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# **AUTOWEIGHTION**

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#### letters to the editor

from page 14

#### Straightening the Record

Dear Sir:

The article beginning on page 97 of the November issue of Chemical Engineering Progress has just been called to my attention. Inasmuch as the article was attributed to me, but I did not write it, and inasmuch as it gives a false impression concerning the contributions of my colleagues, I hope you will permit me space in which to set the matter straight. The circumstances under which the interview occurred were not conducive to good reporting and your representative is probably not at fault.

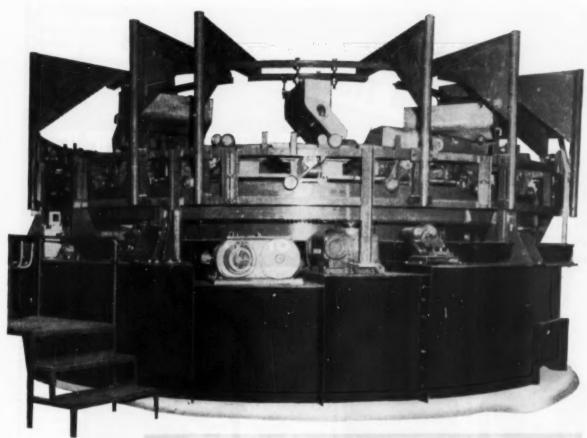
The article is unfair to Professor Y. P. Chang in that it implies he wrote his paper as an extension of the work of Kutateladze. Actually, Professor Chang was unaware of Kutateladze's work and Dr. Chang's contribution is one of those rare cases when a man gets a flash of inspiration all by himself. Professor Chang's paper was written in isolation from the main streams of technical activity. He has attempted to bring into existence a "unified theory" of convection in which boiling is a special case of the more general problem and his work is in no way a follow up on Kutateladze.

The article is also unfair to N. Zuber (whose initial was improperly given) in that it implies his paper is an extension or elaboration upon Professor Chang's. While both the Chang and Zuber papers are concerned with wave motions, one has only to read the two papers and the comments written by each author concerning the other's contributions to see that they are pursuing widely divergent paths!

MYRON TRIBUS,

Los Angeles, California

As Professor Tribus infers, the various distractions which sometimes take place during press interviews can result in interpretations which after publication may not reflect the exact meanings intended. Apparently this has happened, and C.E.P. hopes that Professor Tribus' friends mentioned above will realize that both his and C.E.P.'s efforts were intended to attract reader attention to truly dramatic achievements in an area of highly fundamental investigation likely to be overlooked, and there was no intention of minimizing the contribution of anyone in the field.—Ed.



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#### Nixon Warns Eng'g Education & Practices Must Keep Pace

Chicago Ill. March 19.—Rapid further growth and extension of American scientific and technological activities were termed a major need of this nation by Vice-President Richard M. Nixon, speaking before the

of this nation by Vice-President Ric All-Congress Banquet of the 3rd (1958) Nuclear Congress, managed by the A.I.Ch.E. Mr. Nixon also asked that basic research as related to space development be freed from the pressures of military necessity, called for more rigorous education of our youth, and encouraged more person-to-person exchanges as one way of "waging peace to offset negative propaganda."

Mr. Nixon called our scientists "the equal in quality of those of any other nation," and said that, in spite of its weaknesses, our educational system provides "probably a better education for more people than is available in any nation in the world today."

Saying that increased emphasis is needed on training more scientists, he warned that "we must not overlook the importance of making sure that our engineering education and practices keep pace with modern scientific technology."

The general public, Mr. Nixon feels, has already begun to show waning interest in both outer space and the broader implications of scientific progress. He sees it "the responsibility of every knowledgeable citizen to keep this interest alive so that we can maintain the national effort upon which our security and continued progress depend."

"It is not," continued the Vice-President, "that we want to make all our citizens into scientists. What we must do is to provide for the non-scientist the insight and understanding with respect to science which we have historically sought to give to all of our citizens in the field of humanities."

More rigorous educational processes, coupled with more classrooms and improved salaries, prestige and support for our teachers, were among Mr. Nixon's musts.

The matter of which type of government agency should have the primary responsibility in the development of our outerspace program was given important emphasis by the Vice-President. "There can be only one answer," he began. "We must not be

limited by military needs or military thinking in exploring outer space, just as we are not so limited in developing nuclear energy . . . we must be motivated in developing our space program not by fear, but by the positive desire to explore one of the most challenging frontiers science and mankind have ever faced. The best way to insure that the scientist in this field makes the greatest contribution is to

Continued on page 22

#### 55 Million Pounds of High Density Polyethylene

Two new Bakelite Co. (Carbide) plants will add 55 million pounds of high density polyethylene to the nation's annual capacity. One plant, at Institute, W. Va., is already in production, is producing 30 million pounds a year of Ziegler-type material with a density of 0.950. The second, at Seadrift, Texas, is scheduled to be on-stream within a short time, will make 25 million pounds a year of Phillips-type resins at a density of 0.960. This will give Bakelite a wide position in polyethylene, ranging from 0.915 material all the way up to 0.960 material. Questioned on DuPont's composition of matter claims, Bakelite president, R. K. Turner, said that his company is carefully investigating the situation, although DuPont's claims are more likely to affect Phillips and Ziegler, according to Bakelite officials.

#### Direct Reduction of Iron Ore

Pig iron and semi-steel has been produced by the direct reduction of iron ore in a prototype plant at Niagara Falls. The process used, the Strategic-Udy Process, was developed jointly by Strategic Materials Corp. and Koppers Co., uses a rotary kiln and an electric furnace. Advantages claimed include use of low-cost carbon sources as reducing agent (coal, lignite, peat), applicability to almost any type of ore, feasibility of small units at ore site. Main limiting factor is need for comparitively low-cost electric power to be economical.

#### **Chemical Plant Improves River Water**

At Metal and Thermit's newly-dedicated plant in Carrollton, Ky., water used in the processing and discharged into the Ohio River will be purer than the water in the river. The new plant will make a series of butyl-tin and other organometallic chemicals.

### **Process Heat Reactors Best Domestic Use of Atom**

Reprocessing Hits Snag, Says Spector

The integrated process heat atomic reactor which supplies process steam, direct and supplementary radiation, and salable isotopes, is the most economocally promising reactor for the domestic scene for years to

come, says Norman Spector, president of Vitro International, speaking at the A.I.Ch.E. luncheon in connection with the 3rd (1958) Nuclear Congress in Chicago.

In the first place, Spector pointed out, present power and propulsion programs are in a stage where a heat program could proceed almost as a by-product, with minimum development costs.

Secondly, by concentrating on the relatively low temperatures involved, the difficult problem of the very high temperatures needed in power reactors can be avoided. This means that reactors already well along in development could be employed. Also, since the application is almost direct, with no conversion to a second form of energy such as electricity, a given reactor will produce four times the thermal kilowatts for process use than can be obtained as equivalent electrical kilowatts. At the same time, the cost of conventional fuels used by the process industries is generally much higher than that paid by electrical plants, hence the heat reactors would have more economical immediate application. And because, unlike electricity, the heat must be generated at the plant site, small reactors will be required, which will mean less investment.

Thirdly, the market is probably very large, since the total amount of energy consumed by the process industries is several times that used for the generation of electricity. More specifically, it has already been suggested that current versions of PWR and BWR reactors appear to be not too far from generating steam at costs which compete with coal at \$8.00 per ton, or fuel oil at 6 cents a gallon.

#### Reprocessing Snag

At present, nuclear fuel reprocessing is carried out by AEC alone. But this area has been cited as an example of where private industry-especially the chemical industry-can come forward and take over, but where private industry has failed to do so. The fault, according to Spector, is not industry's but AEC's.

AEC has set up the basis on which private industry can understand what is expected in this area, and what they must do to get into it. Unfortunately, Spector said, after soliciting interest by industry, AEC has turned down all proposals from industry as unacceptable. The reason, as Spector sees it, is that AEC has made the ground rules so severe that the result

was all but a foregone conclusion.
"On the face of it," Spector said, "This is a discouraging picture for industry. We must amortize at something like 15% a year, allow for land, taxes, insurance, cover our process risks, consider process obsolescence, and then try to make a profit. It seems small wonder then that industry cannot compete with Government even when given a 15% differential in price."

#### Breakthrough Seen In Control Of Atom-Use

The United States has probably the most extensive power reactor development experience of any nation. And United States industry is currently much in need of markets for its specialized designs and products, which are primarily good for large-scale nuclear reactor installations. The probability for a large-scale domestic program for power reactors is bleak. On the other hand, the foreign market has taken an upturn.

Key factor for an active American program abroad is the formation, and successful initial operation, of the International Atomic Energy Agency, with headquarters in Vienna, according to Robert McKinney, chairman of the group which came up with Continued on page 21

#### Scramble For Key Overseas Atomic Power Plant

On the industrial side of the international picture, the Chicago Nuclear Congress showed the intense struggle among manufacturers for the contract to build a key atomic power station

The station, of 150,000 kw capacity, will presumably be built starting next January on a site between Rome and Naples with \$50 million of World Bank funds. Completion before 1962 is hoped for. Owners and operators will be SENN, an Italian syndicate of public and private utility firms.

Bids for SENN are likely to be submitted on April 3rd, by eleven groups-four U. S., five British, one Canadian, and one French. The United States groups are: Westinghouse & Kaiser, G-E & Ebasco, B. & W. & H. K. Ferguson, Atomics International & Bechtel. All bids are to be studied first by an international panel of atomic power experts serving World Bank, then SENN's own consulting engineering associate, Internuclear Co. of St. Louis (the Rome staff is headed by Marvin Fox, formerly of Brookhaven.)

Italy offers a peculiar combination of circumstances which make atomic power attractive-even at today's costs. Other nuclear power plants are planned in Milan by SELNI (another group) costing \$40 million through Westinghouse, and a smaller plant by still another group called SORIN. In another part of Italy, AGIP Nuclear proposes a plant of British design.

Indecision on the part of the U.S. with regard to leasing arrangements and charges for nuclear fuel for American designed reactors, is cited as giving the British some competitive advantages, for the time being. If Mr. McKinney's remarks can be interpreted as presaging what our governmental policy may be, then the concern in this area may be shortened.

### **Engineer Employment Trend Upward?**

SCOPE

U. S. Statistics Show Rise

Recent statistics compiled by the Professional Placement Network of the U.S. Employment Service during the last few months reveal what could be regarded as an interesting trend. Arthur Motley of the Department of Labor points out, however, that the figures are only a small sample because the Employment Service receives only a fraction of the requests for professional personnel. Requests for engineers are given (right) for the period from November, 1957, to March, 1958.

The marked need for more civil engineers would appear to be related to the Government's road building program, while the call for more electricals can probably be traced to the stepped-up missile schedule. It is interesting, too, that demand for chemical engineers, which declined from November to February, also shows a slight rise in March. Figures for the months to come will bear watching.

#### McKinney-continued

from page 20

the famed McKinney report on atomic energy, and now permanent American representative to IAEA.

can representative to IAEA.

Describing IAEA as a "political break-through" toward an inspection system to enforce international agreements controlling the use and disposal of fissionable materials, McKinney addressed a banquet of the Atomic Energy Management Conference, one of the activities of the 1958 (3rd) Nuclear Congress, in Chicago.

As to the importance of this breakthrough, McKinney declared, "We have now the prospect that men and women everywhere can watch the building of supplies of nuclear fuels in the hands of their neighbors, or even of their potential enemies, without fear that they will be used as weapons."

He likened IAEA to a business venture in which we and 63 other nations have invested. The U.S. is paying a third of the first year's \$4 million operating budget. Eventually, he said, the agency may earn enough income from production and trading of radioisotopes and other related commodities to pay its own way.

Mr. McKinney expressed gratitude at the participation of Iron Curtain countries, terming this essential to the ultimate goal of world wide peaceful use of atomic energy.

	Nov. 27	Jan. 3	Feb. 1	Feb. 25	Mar. 25
Chemical	173	158	161	113	138
Metallurgical	57	60	54	52	89
Civil	291	265	234	543	831
Electrical	621	632	616	960	917
Industrial	114	112	112	149	148
Mechanical	706	624	514	658	811
Mining	4	2	4	2	2
Total	1966	1853	1695	2477	2936

#### **Higher Rate-Urged for Government Consultants**

The National Society of Professional Engineers has come out for a maximum per diem rate of \$100 for temporary consultants engaged by the Federal Government. Present rate is \$75. NSPE points out that "the Federal Government deserves and is entitled to the very best engineering talent obtainable," argues that the current rate is "insufficient for the economically feasible performance of consulting engineering services."

In recent months, NSPE has consistently advocated better pay for Government employed engineers, particularly at the higher grades, and more equitable Civil Service rules.

#### Scientists' Status

Recently (Scope, January '58) CEP reported concern on the part of one of the Administration's outstanding members, as to whether scientists should be allowed to have responsibility in the area of what, scientifically, our nation should attempt. Now the staff of the Senate Government Operations Committee, in a letter of transmittal accompanying a report analyzing legislation to establish a Department of Science and Technology, has come up with the following: "Although the free peoples of the world have never placed so much reliance on so few individuals, a majority of the scientists have so far resolutely refused to recognize their responsibilities and recommend appropriate remedial legislative action. Instead, they have been content to retreat behind a screen of fear of our democratic processes. . . . As it becomes more and more evident that proposals which scientists may advocate will be based upon knowledge of their special fields of science, and the limited areas of their personal activity and the maintenance of the status quo, in complete distrust of our system of government and without apparent regard for the need for an overall coordination of science programs under responsible administrative authority, it will become more imperative that the Congress act in the best interests of the people. . . . " The letter is signed by the Staff director Walter L. Reynolds. The report itself said, with reference to a Department of Science: "About the only alternative suggestion that has come to the attention to the staff has been that all basic science fuctions, whether Government controlled or supported, should continue to be placed under the exclusive administrative jurisdiction and control of scientists and the status quo maintained, except for increased funds." In the listing of "Educational and organizational representation" in the table of contents of the report, no engineering society is listed, and only two engineering schools: Cal Tech and M.I.T.



### SCOPE President Proposes Civilian Space Agency Plan

Ewell's 10-Point Policy for U. S. Education

Washington Feedback-President Eisenhower sent to Congress recently a message proposing a new National Aeronautics and Space Agency, into which the National Advisory Committee for Aeronautics

would be absorbed (Scope, March '58). Certain provisions of the President's proposal have stirred up lively discussion around Washington engineering and science circles. In addition to this, chemical engineers are actively discussing a report made to them recently by Raymond H. Ewell (just back from India and the U.S.S.R.) that makes specific recommendations regarding our national

educational policy.

The President's plan for NASA would limit it to projects not primarily associated with military requirements. NASA would be headed by a director appointed by the President, by and with the advice and consent of the Senate. To assist the President, and the director of the agency, an NASA board would be appointed by the President. Several members of the board should be from the government agencies with the most direct interest in aeronautics, space science and technology. To assure that military factors be considered by the board, at least one member should be appointed from the Department of Defense. Members would be appointed from outside the government, would be eminent in "science, engineering, technology, educa-tion, or public affairs and be selected solely because they have established records of distinguished achievement." NACA has been given the job of preparing full explanation of the proposed legislation and its objectives.

Washington engineering circles are buzzing because the President, in his message, recommended that NASA be empowered to pay whatever salaries are necessary to get top talent without regard to existing regulations or classifications. What this would do to the Civil Service system is a major

topic of conjecture.

There seems little question but what the proposed NASA will be approved by Congress, and that the funds, shortly to be asked for by the Bureau of the Budget, will be approved. As to the matter of salaries, this is something else again. Expect resistance on this point.

**Ewell's Plan For Education** 

Just back from the U.S.S.R. and India, Raymond H. Ewell, assistant

to the Chancellor of the University of Buffalo told Washington chemical engineers recently that the most important factor about Soviet accomplishment is its rate of growth. "If we retain our past rate of economic growth and they continue their best economic growth, they would equal us in 15 to 20 years," said Ewell.

Education, thinks Ewell, is an important key to our meeting Soviet competition in the future. Dissatisfied with most of the bills now before Congress, Ewell has come up with "A policy for United States Education" which comprised the following:

1-Recognize the importance of education . . . 2-Make education a cardinal item of public policy . . . 3-Decide we must invest more for education . . . 4-Raise scholastic standards and expected levels of achievement . . . 5-Make elementary and high school curricula more rigorous . . . 6-Introduce better methods of motivation and counseling . . . 7-Raise entrance standards for colleges, perhaps having Federal standards... 8-Institute a broad program of scholarships . . . 9-Recognize science as an important part of our culture . . 10-Make more of an effort to identify differing intellectual capacities and needs of students and provide spe-cialized education according to these needs. (Joseph L. Gillman, Jr.)

\* Ewell addressed a meeting of the National Capital Section of A.I.Ch.E.

(NIXON) . . . from page 19

keep him free from immediate military necessity."

Concern was expressed by the Vice-President regarding the effect of anti-U.S. propaganda on what much of the world believes about us-even in the advanced countries that comprise western civilization. To counter this effect, Mr. Nixon cited "one of the most effective ways is through expanding person-to-person contact and people-to-people understanding. I speak not only of those exchanges arranged and financed by government. Even more effective are the activities abroad of technicians, engineers, scientists, and representatives of private industry and foundations.'

"As a government and as a people," continued Mr. Nixon, "we must wage peace not only in what we do but

in what we say . . ."
With regard to controlled nuclear fusion the Vice-President sees "limits of achievement beyond calculation."

"From the physical standpoint, at least, man will be the undisputed master of his universe. We can for the first time in world history wage a winning war on poverty and destitution, on hunger and disease.'

To the engineers, scientists, and business leaders assembled in his audience, the Vice-President concluded: "No group in the world can affect more the outcome of this decision than those gathered in this room . . because as you develop unlimited power for peace you provide for mankind the means by which he can finally eliminate the course of war."

#### Controlled Weather Seen As Weapon

In a report submitted recently to the White House, an 11-man Advisory Committee on Weather Control warned that Russian progress in large-scale weather control could present very real dangers to the security of the nation. Possibilities suggested included melting of polar ice caps with a resulting rise in the level of the oceans, changing the pattern of rainfall on a worldwide scale. The Committee urges speeded-up American research in the field.

#### **Number One American Economic Problem**

Better distribution of the world's wealth by economic aid to underdeveloped countries was labeled as the major U.S. economic problem by 17 out of 48 Free World experts in a symposium organized by the Committee for Economic Development. Speakers included Lester Pearson, Jean Monnet, Paul Spaak. Runner-up problems were inflation and urban redevelopment.

# I.S.I. CHEMICAL N

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#### ISOSEBACIC® Acid Process Covered by 8 U.S.I. Patents

Synthesis of U.S.I.'s new intermediate for the plastics industry, ISOSEBACIC Acid, is detailed in a series of eight patents issued on December 17 of this past year to Dr. Charles E. Frank and other members of the company's research laboratories. Dr. Frank is discussing the material contained in these patents before the alkali metals symposium at the ACS meeting in San Francisco this month.

The new intermediate is a mixture of sebacic acid, 2-ethylsuberic acid and 2.5-diethyladipic acid - the latter two compounds being relatively unknown until the develop-ment of this synthesis. Here are the patent numbers and the subjects they cover: USP 2,816,913-Preparation of Substituted

USP 2.816,914—Dimerization Process
USP 2.816,914—Dimerization Process
USP 2.816,916—Dimerization Process
USP 2.816,917—Selective Process for Dimerization of Unsaturated Hydrocarbons
USP 2.816,918—Carbonation Method
USP 2.816,919—Method of Preparing Acyclic

Carboxylic Acids
USP 2,816,935—Process for the Preparation of

Alkali Metal Derivatives of Conjugated Diolefins and Vinyl Aromatic Compounds USP 2,816,936-Process for Formation of Dialkali Metal Dimers of Diolefins

A plant to produce ISOSEBACIC Acid in commercial quantity is now starting up at U.S.L's major chemical complex in Tuscola, Illinois. Potential applications of the new intermediate include the manufacture of plasticizers, ester lubricants, alkyds, polyamides, polyurethanes, reinforced plastics and in chemical synthesis.

#### New Motor Pump Designed To Move Liquid Metals in **Nuclear Power Reactors**

A new type of pump has been developed to circulate liquid metal coolants such as sodium and sodium-potassium (NaK) at high temperature through hermetically sealed systems in nuclear power plants.

The prototype for the new pump was tested at temperatures up to 1,265°F. After 3,500 hours of operation at temperatures constantly above 1,000°F., inspection showed all parts of the pump to be in excellent condition.

Since some liquid metals are not only chemically active but also become radioactive when used as coolants in nuclear reactors, the liquid metal pump is hermetically sealed to make it leak-proof. It can be obtained in capacities ranging from 150 to 5,000 gallons per minute at operating temperatures up to 1,600°F.

The operating temperature of the new pump motor is said to be independent of the tem-perature of the liquid metal being circulated, permitting operation in reactor systems where temperatures are even higher than the

1.265°F used in testing.
Other equipment for handling liquid sodium is discussed in a booklet entitled "Handling Liquid Sodium" which is published by U.S.I.

## Mallory-Sharon Zirconium Plant Comes Onstream at Ashtabula, O.

2,000,000 Pound-Per-Year Plant Also Produces Hafnium

The new Mallory-Sharon Metals Corporation is owned one-third each by National Distillers, P. R. Mallory and Sharon Steel. Zirconium sponge and platelets are now in production at the company's new plant in Ashtabula, Ohio.

ance is desired.

#### Moffett Becomes Assistant Sales Manager for U.S.I. Polyethylene Resins

John K. Moffett, Jr. has been appointed as Assistant Manager of PETROTHENE® Polyethylene Sales at U.S.I. Mr. Moffett graduated from Yale in 1948 and has been employed since that time by U.S.I. in various capacities. He was supervisor of the company's sodium

peroxide plant, head of sodium peroxide sales, and at the time of his new appointment was in a sales development position for U.S.I. PETRO-THENE polyethylene



#### U.S.I. Building Tantalum-Columbium Pilot Plant

U.S.I. is constructing a pilot plant to produce tantalum and columbium metals in Cinsite of the U.S.I. Research Laboratories. Part of the same facilities that were employed for piloting zirconium and titanium will be used in the new pilot unit, which is expected to be onstream shortly.

Capacity of the pilot plant will be one ton of combined metals per month on a one shift per day basis, three tons per month on a roundthe-clock basis. The two metals will be produced in approximately equal quantities although variations of from 10% tantalum up to 60% tantalum are possible, depending upon the ore used.

The tantalum and columbium (also called niobium) will be produced by a U.S.I.-developed sodium reduction process. A sodium reduction process is in use at the Ashtabula, Ohio zirconium plant of Mallory-Sharon Metals, which is one-third owned by U.S.I.-National Distillers. A related process will also be used in the Mallory-Sharon titanium plant now under construction at Ashtabula.

Pilot operation and initial market development programs for tantalum and columbium will be undertaken by U.S.I. independently of its association with Mallory-Sharon Metals. However, it is expected that any commercial facilities to be MORE

built after the pilot plant pro-

Part of the processing equipment at the Mallery-Sharen Metals zirconium plant, new onstream at Ashtebula, Ohio.

tricity to the commercial grid of the Duquesne Sodium Reduction Process Employed

Half the output of the installation is committed for the next five years under contract with the Atomic Energy Commission. The balance

is available to industry in both commercial

and reactor grades for nuclear work as well as

for structural use where high corrosion resist-

platelets are also produced as an adjunct to the zirconium operation. Hafnium, because

of its ready absorption of neutrons, makes excellent control rod material in reactor cores.

It is in fact used for that purpose in the Shippingport installation now delivering elec-

Hafnium tetrachloride, oxide, sponge and

The new plant is the first to make zirconium sponge and platelets employing semicontinuous production techniques developed by the U.S.I. research group. These techniques involve the use of sodium as the reducing agent for zirconium tetrachloride, and yield sponge of greater purity as a result. The method, which is also being applied to other metals such as hafnium and titanium, tantalum and columbium (niobium), has the advantage over other processes of a lower initial investment cost.

Mallory-Sharon Metals has been granted an exclusive license to use this process. The sodium for the process comes from the U.S.I. sodium operation three-quar-ters of a mile from the new MORE

plant.

April

# **U.S.I. CHEMICAL NEWS**

1958

#### CONTINUED

#### Zirconium Plant

Zirconium Platelets Non-Pyrophoric

Reactor and commercial grades of zirconium are being supplied by Mallory-Sharon Metals in the form of sponge, platelets, unalloyed zirconium and zircaloy ingots and mill producta. Platelets—irregular, flake-like pieces about the size of dimes, and quarters—are nonpyrophoric and non-hygroscopic. They insure greater safety during handling and shipping. They can be compacted for melting as easily as sponge and with virtually no waste. They are of extremely high purity, being almost completely free of sodium, magnesium, chlorides, hydrogen and moisture.

#### Zirconium Role in Reactors

Reactor-grade zirconium is essential as structural material for atomic reactors and for cladding uranium because of its ability to let neutrons pass through, thereby permitting maximum fuel efficiency of the reactor. Zirconium also has extremely high corrosion and heat resistance, vital to atomic energy applications. Hafnium, always found associated with zirconium in the natural state, must be removed in an extra refining step in the manufacture of reactor-grade material, because of its neutron-trapping properties. Hafnium does not interfere with zirconium's corrosion resistance, however.

#### Zirconium Role in Chemical Industry

Commercial-grade zirconium, with 1-3% hafnium content, shows great promise for the chemical process industries. It has excellent resistance to acids, alkalies, chlorine and chlorides, corrosion and heat, combined with strength, ductility, light weight and good machining properties.

#### CONTINUED

#### Pilot Plant

gram is completed, will be owned by Mallory-Sharon Metals.

Primary market for tantalum is expected to be the chemical process industries where it has long been used because of its chemical

inertness, especially to hydrochloric acid. Columbium, or niobium as it is often called, has been in demand as an alloying material for steel. More recent interest in this metal stems from its properties of low neutron cross-section, high-temperature strength, high melting point and the insolubility of columbium oxide in the metal at elevated temperatures. This combination of properties makes it a material with considerable promise for nuclear applications, including gas-cooled atomic reactors, as well as certain applications in supersonic aircraft and gas turbines.

#### Black Polyethylene Used For Ventilating Systems In Chemical Laboratories

Ventilating systems for laboratories, which will withstand corrosive fumes without deteriorating or discoloring, are now being fabricated completely of black, all-weather polyethylene. Since polyethylene compounded with black is expected to give 15 to 20 years of service, its substitution for metal should reduce maintenance and replacement problems substantially on fume hoods, exhaust stacks, fans and fittings.



Black polyethylene fume hood and stack exhaust acid vapors without deteriorating, cut replacement costs (photo courtesy American Agile).

#### TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

For corrosion studies, two special solutions are now offered which isolate surface films from metals. An iodine-methanol solution is designed for aluminum alloys containing no copper, an iodine-methanol suifosalicylic acid solution for aluminum-copper alloys.

He. 1346

New 24-page booklet on titanium—includes physical and mechanical properties, metallurgy, corresion resistance, methods of machining, forming and welding.

Atomic lamps said to provide power-free, uninterrupted light for up to 10 years have been developed. They use radioactive krypton—85 gas to excite specially processed, hermetically sealed phosphor crystals.

Ro. 1342

Cost of polyurethane installations foamed-inplace can be estimated with a nomagraph char now available. Thickness, area, density of stock and price per pound must be known. Chart elimnates need for calculation.

Concentrated (98%) ethylene diamine can now be obtained in commercial quantities for use by manufacturers of textile finishing and polyamine resins, synthetic wazes, rubber chemicals, fungicides, pharmaceuticals.

We. 1344

New pelyethylene-te-metal adapter has been devised to connect polyethylene and metal pipes and fittings without using clamps. It consists of a threaded polyethylene gasket between metal nut and tailpiece.

No. 1345

4.4-Diaminostilbene is available in laboratory quantity. It is readily soluble in methanol and ethanol, sparingly soluble in carbon disulfide, benzene, hot water. Forms aso dyes, useful as organic intermediate.

No. 1346

Ten new atomic models for constructing organic metal chelates are now on the market. They are scaled to a magnification of 1.5 X 10. Four models represent the central metal atoms. Others used for rest of chelate.

No. 1247

New silicone fluid of lew viscosity has been introduced for use as a damping medium and hydraulic fluid. Is claimed to have lower viscosity-temperature coefficient and lower pour point than most methyl silicone fluids. No. 1348

Pyroglutamic acid (L-2-pyrrolidone-5-carboxylic acid) is now offered in pilot plant quantities. This heterocyclic amino acid has 2 reactive positions—a carboxyl and a cyclic amide group. Sugquested as intermediate and for resolving racemic mixtures of amines.

#### PRODUCTS OF U.S.I

Alcohols: Ethyl (pure and all denatured formulas); Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL® M, ANSOL PR.

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOLIO, Diethyl Oxolcie, Ethyl Ether, Acetane, Acetacetanide, Acetaceta-Ortho-Chloronilide, Acetacet-Ortho-Taluidide, Ethyl Acetacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sadium Ethylate, ISOSEBACICS Acid, Sebacic Acid, Urethan U.S.P. (Ethyl Carbamate), Ribeflavin U.S.P.

Pharmacoutical Products: BE. Methionine, N-Acetyl-DE. Methionine, Urethan USP, Riboflavin USP, Intermediates.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrote, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Sodo, Chlorine, Metallic Sodium, Sodium Peraxide, Sodium Sulfite, Sodium Sulfate.

#### PETROTHENE® Polyethylene Resins

Development Chemicals: Ethylaluminum Sesquichlaride, Methylaluminum Sesquichlaride, Monomethyl Hydrazine, Triethyl Aluminum, Trimethyl Aluminum, Unsymmetrical Dimethyl Hydrazine.

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# Some Things to Think About Steam Traps

...in order to get high operating efficiency and a minimum of maintenance

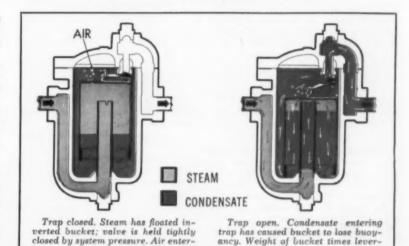
The gentleman who invented the wheel had a basic idea and so far no one has come up with anything better for the purpose.

If you'll pardon us for a little overemphasis on the significance of steam traps, we'd like to liken one of them to the wheel.

In 1911, when the first Armstrong inverted bucket steam trap model was announced to the world, or at least that part of the world that modest advertising and sales budgets would cover, it was not received with equal enthusiasm by all (especially old-style trap makers). But, like the wheel, it managed to find its way into general use. And, nothing better has ever turned up for the purpose of draining condensate. As a matter of fact, the Armstrong trap has been very widely copied. Today, there are more inverted bucket traps draining process equipment than any other kind. Of these, there are more Armstrongs.

If this sounds like the boasting of a proud parent, give consideration to some fundamental requirements not met by all traps:

- 1. A steam trap should not leak steam. Some traps do, you know, because of the nature of their operating principle. No steam ever gets to the Armstrong trap orifice. The valve is always water sealed.
- 2. A steam trap should vent "air" as fast as it accumulates otherwise temperatures are reduced and corrosion is a problem. The Armstrong trap handles air very nicely. The vent in the bucket permits air to accumulate in the top of the trap, from where it is discharged when the trap opens. For extreme conditions like draining paper machine dryers, some jacketed kettles and certain other units, the vent is sized larger for the job. And, for handling big volumes of air during warm-up, a bucket with an auxiliary thermic vent really speeds up heating.
- 3. A steam trap should discharge condensate at steam temperature if you want to get



maximum efficiency from the unit drained. And most people certainly do. If you have to wait for the condensate to cool, it's almost impossible to maintain maximum temperatures and prevent air build-up. You guessed it—the Armstrong trap opens for water, without dependence on temperature.

ing trap passes through bucket vent

and accumulates at top of trap.

- 4. A steam trap should be suitable for any return system. The Armstrong trap works just the same whether discharging to atmosphere, back pressure or vacuum. It has been conclusively proved that flash steam resulting from use of a bucket trap does not cause a problem in vacuum return systems. The flash condenses rapidly. It's the leaky traps that cause the headaches.
- 5. A steam trap should not be a "prima donna". Some kinds of traps take an awful lot of care and coddling. The Armstrong trap is a rough and ready type with a hardened chrome steel constitution (valve and seat, to be exact). It cleans itself of ordinary dirt and scale without choking up. Its 18-8 stainless parts stave off rust and corrosion. It resists wire-drawing and wear remarkably well. In fact,

it stays on the job longer with less attention than any trap ever produced. Unless you live in Siberia, you can probably find a user around the corner who will tell you so from experience.

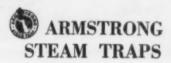
age pulls valve open. Air is dis-

charged along with condensate.

- 6. A trap should not be an "orphan". With Armstrong traps you can always get prompt service and parts from nearby Factory Representatives and stocking distributors as well as from the factory.
- 7. A trap should have a guarantee. The Armstrong trap is unconditionally guaranteed to give you complete satisfaction (as to doing its job, that is). If it doesn't, you can get your money back.

If you'd like to buy some of these excellent steam traps, call your local Armstrong Representative or write Armstrong Machine Works, 9761 Maple St., Three Rivers, Michigan.

ASK FOR the 44-page Steam Trap Book, free on request without obligation.



#### Combustion International

SIXTH SYMPOSIUM (INTERNATIONAL) ON COMBUSTION, The Combustion Institute, Reinhold Publishing Company (1956), \$28.

Reviewed by R. S. Levine, Rocketdyne, Division of North American Aviation, Inc., Canoga Park, California.

This volume compiles 125 separate research papers in the field of combustion, most of which were presented at the Sixth Symposium held by the Combustion Institute (a nonprofit professional society) at Yale University, New Haven, Connecticut, August 19-24, 1956. If one assumes the average cost of each investigation is \$40,000, this compilation represents \$5,000,000 worth of highly qualified research effort.

Although the papers are grouped into several categories, there is no attempt to summarize the often conflicting views of the individual authors. Résumés of three panel discussions held during the Yale meeting are included to point up some of the pertinent problems in combustion.

The categories listed in the volume are:

- Structure and propagation of laminar flames.
- Structure and propagation of turbulent flames.
- 3. High-speed reactions.
- 4. Flame stabilization in fast streams.
- 5. Ignition.
- 6. Combustion of solid fuels.
- Combustion of explosives and solid propellants.
- 8. Evaporation and combustion of droplets and sprays.
- Experimental and analytical techniques in combustion.
- 10. Applications of combustion.

Included in the foregoing are invited survey papers by recognized authorities on laminar flame propagation, the structure of the laminar flame, heat conductivity in chemically reacting mixtures, the combustion of solid fuels, combustion of fuel sprays, and pyrometry of high velocity gases.

The importance of this work to chemical engineers working in the field of combustion is obvious. This volume could not serve as a textbook, but these papers and the literature searches they summarize represent a nearly complete status of this subject as of 1956. Most of this work will probably not be published elsewhere. Engineers with problems involving radiation from flames, droplet phenomena, subsonic gaseous fluid dynamics, high-speed photographic or pyrometric instrumentation, smog generation from incomplete combustion, and the manufacture of chemical intermediates by combustion processes will also find this volume of interest.

#### All about reactors

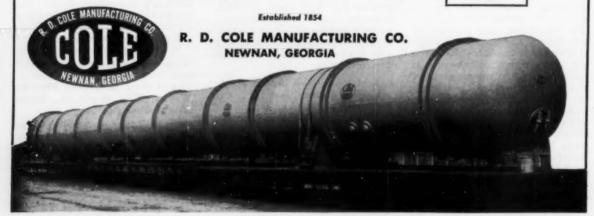
U. S. RESEARCH REACTORS. Prepared by Battelle Memorial Institute for United States Atomic Energy Commission, Washington, D. C. Paper bound (1957), 73 pp., \$1.50.

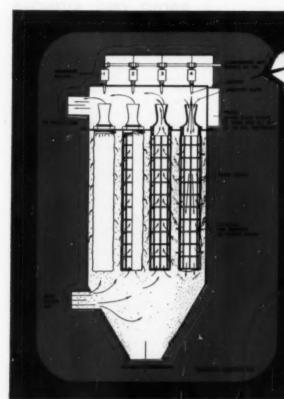
This booklet, prepared for scientists, engineers, and administrators is a summary of technical information on the major types of research reactors developed in the United States. One or two examples of each are described at length as typical, and features of others are illustrated.

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#### **ABOUT OUR AUTHORS**

F. A. Forward, who leads off the technical articles in this issue with a broad look at hydrometallurgy, is at the University of British Columbia, Vancouver. During much of the past ten years, Forward's efforts have been devoted to the development of pressure leaching processes for Ni, Cu, Co, and U. Forward's patents (held alone and with others) have been put into commercial operation in Sherritt Gordon's \$25 million plant at Fort Saskatchewan, Alberta, and Eldorado's \$15 million uranium plant at Uranium City, Saskatchewan. "I suppose the most important contribution was introducing the concept of continuous pressure leaching of base metal ores using compressed air as an oxidizing agent," says Forward.

R. E. Florine, our author on economic planning of Kraft mill evaporators, tells this story to indicate how varied can be the life of an equipment applications engineer. "Several years ago a new pulp mill evaporator went on stream and operated well for a couple of hours until it lost vacuum. We were naturally suspicious of the vacuum equipment, since it is was old, although it appeared to be in excellent condition. A few hours later the evaporator vacuum returned to normal for about two or three hours, and then the trouble reappeared. It took us 60 hours (without sleep) to locate a hole in the barometric leg that was periodically uncovered at low tide in the covered salt water hot well!"

K. B. Higbie is associate director of Research for Beryllium Corporation, and has been responsible for the development of several production processes. Currently, his group is studying fabrication of beryllium and shapes of its oxide. Previously, Higbie spent several years at the Bureau of Mines' Albany, Oregon laboratories as head of the R & D section. M. C. Farmer is staff metallurgist for the Material Advisory Board, National Academy of Sciences. Until recently he served as technical director for Beryllium, and before this was chief of the Metal Working Section of the Engineering Div. of Alcoa's research laboratories.

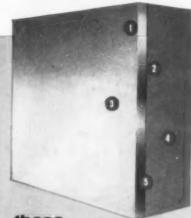
R. K. Finn, well known to CEP readers, is professor of chemical engineering at Cornell, and an authority on bio-engineering. R. Dobry is a research chemical engineer with Pacific

continued on page 30

# CONKEY® EVAPORATOR

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This 3-body triple effect LTV Integral type Conkey Evaporator was fabricated to ASME code throughout in Hortonclad Inconel construction. It is fitted with a two pass, first effect body—complete with a barometric condenser.

A foaming tendency of the chemical solution being concentrated is minimized by use of Conkey patented, built-in preheater sections. This permits each evaporator section to operate on liquors that have been heated to boiling temperature in that body. Economy of operation is insured by use of an external liquor-to-liquor heat exchanger built in multiple sections—so that one section can be cut from the system for cleaning, while balance of system remains in operation.

Compact, unitized "out-of-door" construction such as this is another example of how Conkey "know-how" is helping progressive processors realize the benefits of low installation and erection costs and maximum use of space.

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information about

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This is our New General Bulletin—3354G. It's full of information and data on the chrome-iron and chrome-nickel castings so necessary when corrosion, high temperatures and abrasion must be resisted. It will serve as a general selection guide for those specifying or using such castings.

The bulletin also reviews briefly our experience in both static and centrifugal castings, an experience going back to the pioneering days of 1922 and 1933 respectively. It also tells about our facilities for furnishing castings to any desired analysis, welding, X-ray and gamma ray testing, metallurgical and foundry control.

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#### **ABOUT OUR AUTHORS**

from page 28

Yeast Products, Inc., Wasco, Calif. Previously, he had studied electrophoresis at Cornell.

D. F. Taylor is technical director of the Metals & Fabrication Div. of Fansteel Metallurgical Corp., with which he has been connected since 1925. A chemical engineer, Taylor has developed processes for manufacture of the refractory metals: Ta, Cb, W, and Mo. "My most important contribution," Taylor writes, "was probably the development of methods for the extraction and reduction of tantalum and columbium."

J. R. Harnish, co-author of the article on the halocarbon refrigeration system, heads up air-source heat pump applications on large industrial installations for York Div. of Borg-Warner.

N. E. Hopkins, who has served as director of research for York, is senior engineer in charge of special low temperature installations, many for the armed forces. One of his jobs was the low temperature altitude chamber at the Naval Ordnance Test Station at Inyokern, Calif. Another was the refrigerated hangar at Elgin Field, Fla. which involved 750 tons of refrigeration at  $-67^{\circ}$  hangar temperature.

Another name well known to CEP readers is S. H. Jury, who has just been made full-professor at the University of Tennessee. His most recent field of activity has been with the mathematics of diffusion, continuous ion exchange, and thermal diffusion in a newly developed horizontal column.

George Thodos, co-author of the article on continuous removal of aniline from aqueous solutions, is professor of Ch.e. at Northwestern. The presently reported studies, done with J. M. Iwasyk, stem from pioneer work on mass transfer done in 1943 at the University of Wisconsin by Thodos with B. W. Gamson and O. A. Hougen. Iwasyk is presently continuing his studies at MIT.

George Chenoweth is senior staff member of Spencer Chemical's Process Development Dept. He specializes in pilot plant design and operation on projects which include polyethylene, nylon, high analysis mixed fertilizer, urea, and nuclear energy.

#### Solve Difficult Liquid Processing Problems

with the New



# TURBA-FILM° PROCESSOR

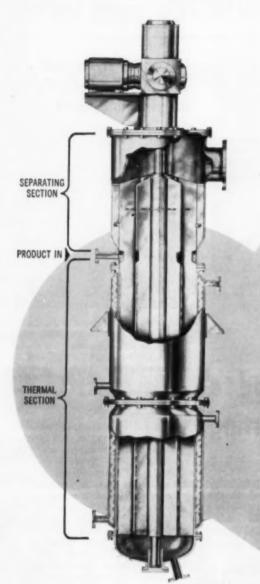
When viscous fluid processing is "bugged" by complex procedures, time-at-temperature-sensitive materials, sluggish control of product quality... look to the new Rodney Hunt Turba-Film Mark II Processor to simplify your problems.

Utilizing a turbulent thin-film technique, the patented Turba-Film Mark II Processor provides mechanically aided heat and mass transfer in one pass, continuously and rapidly, for a wide range of viscous fluids and slurries. It delivers controlled uniformity of product in

concentration . . . deodorization . . . dehydration . . . evaporation . . . heat transfer . . . reaction . . . stripping . . . and other processes.

Short-time exposure and minimum hold-up of the process fluid in the thermal section assures uniform heat and mass transfer, even at high temperature. Foaming is controlled by a mechanical separator and the formation of crust is minimized permitting continuous operation for long periods.

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#### An Invitation

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# PFAUDLER CORROSIONEERING NEWS



Corrosive chemicals travel more cheaply in this truck equipped with Plaudler glassed-steel

tanks. Tanks eliminate costly glass carboys which require considerable handling.

# Glassed steel takes to the road to cut freight on acid chloride carting

A certain fatty acid chloride is bought in such quantity by Lever Brothers that glass carboy packaging takes too much time, costs too much in freight and handling, and presents an intolerable breakage problem.

Lever Brothers asked their carrier, Rogers Cartage Company, to talk with us. The result is the glassedsteel tank truck you see above.

Each of the truck's twin tanks will hold 2200 gallons of the acid chloride or any other acidic chemical except hydrofluoric acid. They will also carry most alkalies at moderate temperatures.

Two different chemicals can be carried simultaneously, since each tank is a separate unit with its own manhole, vents, dip pipe, openings, and bottom outlet drain.

The truck travels 297 miles on each of its trips from Monsanto's plant in St. Louis to Lever Brothers in Hammond, Indiana.

The trailer is a conventional unit.

We made the tanks and mounted them in such a manner that they will take to any existing road conditions. There is plenty of "give" to the glassed steel; in fact, we've demonstrated that a 36" strip of glassed steel can be flexed six inches in both directions without damage to the glass or its bond.

What does Rogers Cartage think of the glassed-steel tank truck? They just placed an order for a second unit.

For more details on this, contact your Pfaudler representative, or write for Data Sheet 29.

Sidelight: When the truck reaches Lever Brothers, it empties its payload into Pfaudler glassed-steel storage tanks which in turn empty through glassed-steel pipes, fittings, and valves. Such total use of glassed steel from receiving to process is not so unusual as you might think, as witness the next story.

#### 100,000th Elyria Unit goes to Hoffmann-LaRoche for vitamin B, work



This 300-gallon reactor is the 100,-000th piece of corrosion-resistant process equipment completed at our Elyria, Ohio plant.

By coincidence the tank was ordered by the Hoffmann-LaRoche Company for producing riboflavin-5'phosphate sodium ester in its Nutley, New Jersey plant.

So great is Roche production of this vital compound, as well as other vitamins and pharmaceuticals, there are literally hundreds of Pfaudler glassed-steel units already to be found in the New Jersey plant.

Some claim that it would not be commercially possible to produce the riboflavin-5'-phosphate without such glassed-steel equipment. The presence of even trace quantities of metals in this vitamin B<sub>2</sub> compound will gradually precipitate out insoluble salts, developing turbidity in solutions of the product.

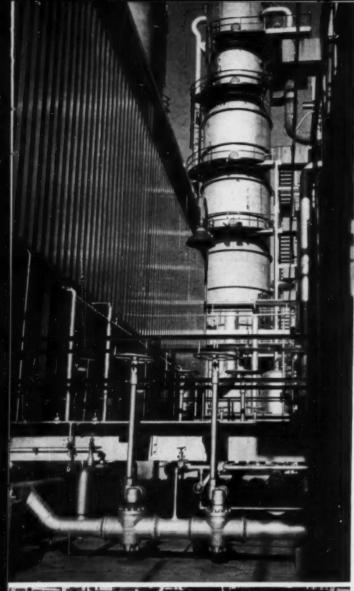
Long ago we worked with Roche to make certain that glassed steel protects the process against entrance of metals. The result is that the complete process is now accomplished in glassed-steel reactors, receivers, piping, valves, etc.

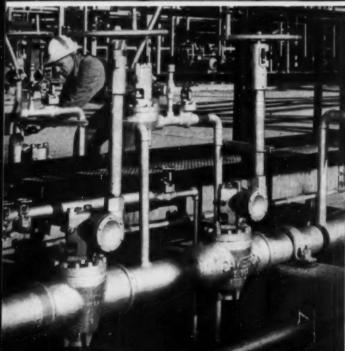
To discover just how complete a line of process equipment is available in Pfaudler glassed steel, write for Buyer's Guide, Bulletin 947.

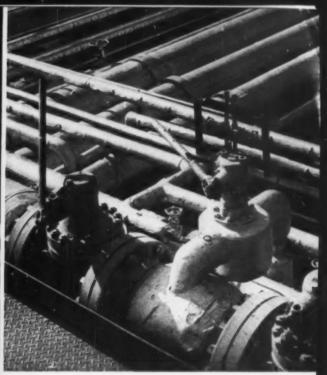
#### THE PFAUDLER CO.

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Sao also Chemical Engineering Catalog, pages 1407 through 1418.







#### LIFT-PLUGS

#### LIFT PROFITS

Because of their unique design, Cameron Non-Lubricated Lift-Plug Valves seal bubble-tight and are exceptionally easy to operate. But these are only two of their advantages. Lift-Plugs lift profits because they require no expensive lubrication program, no special lubricant inventory. This, of course, means no line product contamination and no grease deposits on orifice plates or delicate measuring instruments. They save time and money because they may be welded into the line, eliminating flange costs and the possibility of leaks. When repairs are finally necessary, Lift-Plugs can be made as good as new without removing them from the line. If you are not already enjoying these unusual benefits, call on Cameron to lift profits with Lift-Plugs.

These are Lift-Plug installations at the Delaware Refinery of Tidewater Oil Company.

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#### this

# GOLDEN ANNIVERSARY is your

#### GOLDEN OPPORTUNITY!

# May 1958 CHEMICAL ENGINEERING PROGRESS will be a spectacular issue commemorating the "Chemical Engineers' Golden Jubilee"

The American Institute of Chemical Engineers' 50th Anniversary marks a major milestone in the progress of the Chemical Process Industries, from the celluloid era to today's rocket fuels. From vital discoveries in basic research, through the entire scope of chemical engineering, A.I.Ch.E. will celebrate fifty fabulous years of achievement.

A salute to the past is only part of the celebration. The main theme of the Jubilee program next June at Philadelphia will be "A Look to the Future." Here is the real significance of May Chemical Engineering Progress for all advertisers—chemical engineers dedicated to the growth and development of all chemical industries.

This is truly a golden opportunity for manufacturers to instill both their corporate and their product messages in the minds of responsible chemical engineers—men whose decisions are essential to the purchase and

specification of practically all chemicals, equipment, materials and engineering services in the chemical process industries.

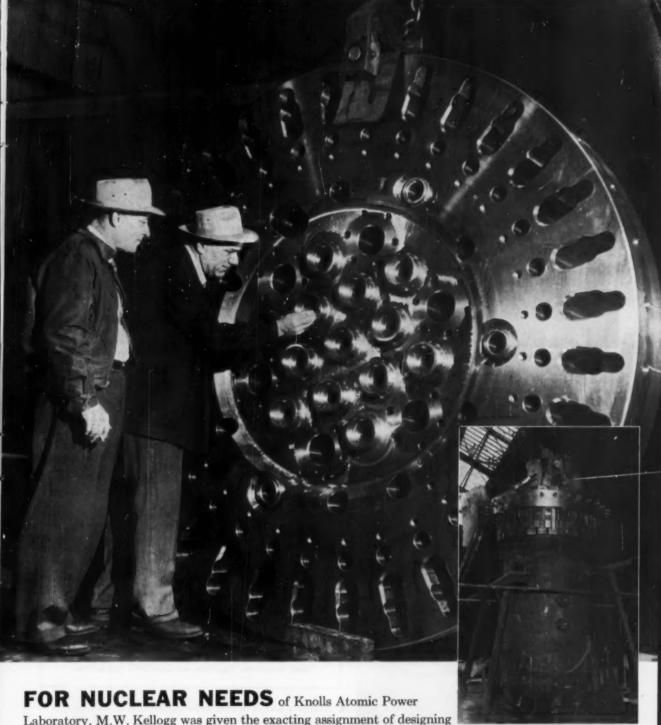
Highlights of May C.E.P. include a History of Chemical Engineering and A.I.Ch.E., and a survey of Chemical Engineering Around the World, plus other fascinating features and timely engineering articles. This matchless editorial selection insures intensive readership.

Take full advantage of this unusual opportunity to invest in your company's future in the growing C.P.I. Join the many advertisers who are planning special product progress stories to relate their company growth to the Golden Jubilee of A.I.Ch.E.

The May 1958 issue of C.E.P. will be a big issue—your big opportunity to get big results. Be sure to reserve adequate space.



Published for chemical engineers by the American Institute of Chemical Engineers 25 West 45th Street, New York 36, N. Y.



Laboratory, M.W. Kellogg was given the exacting assignment of designing and fabricating this complex closure for a "Proof Test Reactor Pressure Vessel." Kellogg also fabricated the complete 32½-ton unit. If these specialized skills suggest a solution to a difficult problem in nuclear equipment or chemical processing equipment, call Kellogg's Fabricated Products Sales Division.

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# First fabricated ammonia still...built at Downingtown for Koppers Company, Inc.

When Koppers Company, Inc., Engineering and Construction Division designed this welded carbon steel plate ammonia still to replace its previous cast iron design, it naturally chose the fabricator with care. Close tolerances were required on positioning of risers, riser slots, bells, trays and weirs. We're proud of the part Downingtown had in this pioneering effort. This still is used for stripping the ammonia from ammonia liquor produced in a chemical recovery coke plant.



### THE UNIT WAS BUILT TO THE FOLLOWING SPECIFICATIONS:

Inside Diameter: 7'0"

Over-All Height: 37'10"

Design Data: 12 psi, 650° F.

Operating Data: 7 psi, 250° F.

Shop Test: 12 psi hydrostatic for 90 min.

Total Weight: 60,000 pounds

Send for bulletins describing our experience and facilities.

Interior of bottom section, showing position of rectangular bells fabricated from stainless steel, type 410. Thirteen trays, with bells.

#### Downingtown Iron Works, Inc.

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# CEP trends / Future of a Recession

Business closed the first quarter of the year with no signs of any change in the downtrend. Bad news accumulated on every front. The only sign of cheer in a gloomy picture was the behavior of the stock market during the first three months. Stocks did not go down

despite the disturbing business reports.

The stock market is a traditional barometer of business things to come, and is supposed to discount events months before they occur. Stocks turned-down last autumn while business was still good, and held up during the first three months of this year when business was obviously bad. However, conditions are always a little different in every recession or depression. Now, for one thing, the market appears to be reacting to the smell of inflation. Inflation means theoretically that property is better than money, because money will decline in buying power. The various proposed measures by the government to stop the decline, including more spending and cuts in taxes, are obviously inflationary. How great the inflation will be depends on how far these measures go.

In this case then, the fear of inflation may be one reason for the strong behavior of the market, making the market no index to the business outlook. Another reason for the buying of stocks in the face of bad news is the enormous amount of money around in bank trust funds, in pension funds, in insurance companies, and in private hands. One big insurance company is reputed to be obliged to invest \$1,000,000 a day. One moderate sized bank invests \$1,000,000 a week. Multiply this by hundreds and thousands of investors and you have a

basis for the stock buying.

Investors of this class apparently believe that if they have money to invest they must invest it day by day regardless of the level of the market or of the outlook. But here the question arises as to what attitude investors will take if they are suddenly slapped with bad news in the form of earnings statements which indicate that dividends are not being earned and perhaps cannot be

paid.

One of the largest chemical companies, for example, will report first quarter income well below dividend requirements, and, unless there is a sudden reversal, will do the same in the second three months of the year, and perhaps in the fall quarter. If business does not turn around then, the firm might be obliged to reduce its dividends.

Faced with unpleasant realities like this, if they occur, and at the moment there is no indication that they will not, the stock market could reverse itself downwards in line with the business trend. In other words there is a possibility that the traditional barometer this time may not be correctly forecasting the business weather.

For one reason, inflation may be theoretically good for stocks, but it is not necessarily also good for business: for one thing, it means higher costs for labor and for

materials.

Reports from Washington now indicate that government economists, who not long ago glibly allowed the President to forecast a business upturn in March, have now changed their tune and are not looking for a change in the trend until the end of the year. According to Federal Reserve Board reports, production has declined 123 since the start of the current recession, more than in either of the two minor set backs since World War II.

Government measures to stem the recession in the form of lowering money rates and reserve requirements have so far had no effect on business nor any appreciable effect on the stock market. In the long run they may prove helpful. But a chemical firm planning to reduce capital expenditures this year, as some are, is not going to spend more money because money can be borrowed at 4% instead of 5%. Correspondingly, an individual who is afraid to buy a house, or who cannot afford to buy a car, is not going to plunge simply because he has less interest to pay. Incidentally as far as consumers go, there is nothing that curtails spending faster than seeing the man next door lose his job.

Another government proposal, not yet concrete or decided, is to reduce income taxes. Here again, it is hard to see any immediate effects on business. A tax cut of course would unbalance the budget, which would be inflationary. But lower corporate taxes would not necessarily mean more plant building, and plant building in any event means months of planning. And if individuals learn that their taxes will be cut \$100 or more, they will

not necessarily run out and spend it.

In the chemical industry itself there are signs of underlying price weakness. There is, certainly for the time being, over-production in a number of basic products. Chemical firms are reluctant to cut unless they are obliged to because they have learned by experience that they gain no volume and lose profits. But unfortunately there is always some one out on a limb who will sell at concession under the counter. This is now going on

in several major products.

On the foreign front there has been the news that Russia is apparently continuing the cold war on the trade front by dumping aluminum and ferro-alloys into Great Britain at well below going prices. The British are considering counter measure in the form of higher duties. While no one is fond of the Soviets, there is a possibility that in this case Russia has more than one motive. It would no doubt like to upset trade in the Western World. But as far as aluminum goes it looks very much as though Russia had a glut that it could not handle domestically. Capacity has been largely increased, and Russia, like ourselves, is probably cutting down production of bombers. Having no civilian consumption to fall back on, it is selling it abroad to get foreign currency. The threat of increasing Russian competition in export markets is not to be ignored.

# Better, Stronger Piping Assemblies

through new Fluor cold-extruded prefabrication





Cold-extruded header, containing 45" miter weld 16-in. outlet nozzle, extruded in 30-in.



Simple, more accurate fit-up...smoother nozzle contours... elimination of reinforcing pads assure important savings

WHEN YOU specify a multiple outlet header, cold-extruded by the new Fluor technique, you obtain a prefabricated piping assembly that offers higher strength, closer dimensional tolerance, smoother surface and greater uniformity. Note these advantages Fluor-forming provides:

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SIMPLIFIED DESIGN: Nozzles or branches can be located anywhere along or around the header pipe.

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FASTER PRODUCTION: Less welding, less inspec tion make possible faster production and quicker delivery.

IMPROVED FIT-UP: Because of uniformly closer dimensional tolerances for each outlet nozzle, fit-up to adjoining piping is simple, accurate.

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Write for Bulletin CE-0.001. EXTRUSION SALES, Fluor Products Company, Paola, Kansas.





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#### THE PLACE TO WORK

The supply and demand for new and recent engineering graduates is undergoing certain changes that should be watched with concern. The reduced level of business activity, levelling-off of recruiting, larger graduating classes, lowered quotas for post-graduate military service . . . are factors already affecting opportunities for careerfulfillment employment. What will be the result of these by June of this year. Or perhaps more important, by June of 1959?

There is wide agreement as to the long range need for increasing numbers of engineers and scientists. The question today is, whether short range fluctuations in the business economy may bring about temporary, but sufficiently large, cutbacks that might result in real harm to future enrollments?

Following the gloom and doom talk so prevalent in the early part of 1950, the chemical industry has accomplished notable gains in helping attract the best young people into careers in science and technology. This has been done by techniques already described in this magazine, and by strong emphasis on the exciting career opportunities ahead for the able and properly trained.

Recently the government has, as we all know, stepped up its emphasis on more science and engineering enrollees. President Eisenhower's scholarship bill, now before Congress, makes clear its intent that preferential emphasis be given candidates for science and engineering training.

The numbers of freshman engineering enrollees has risen from the 1950 low of 34,300 to a 1957 plateau of 78,757.

Yet we now face a paradoxical situation of having arrived at a level of enrollees and graduates long strived for, but at the same time being faced with the real possibility of reduced employment opportunities. Industrial recruiting, as said before, is off. Government opportunities in enlarged scientific programs may, on the other hand, come to account for the difference as far as the graduating class of 1958 is concerned.

Perhaps, from the government standpoint, this is good. But as far as the chemical process industries are concerned, can we afford to let go, by default, into government employment, the type of men we were striving for so competitively such a short time ago?

Certainly, industrial management today has many problems brought on by this recession that call for deference of a great many expenditures, at least for the time being. In the matter of trained professional manpower—specifically chemical engineers—however, it seems almost unnecessary to remind industrial employers of what is so likely to be happening one, two, and more years from now if the employment of men presently available is deferred, and a full crop is not started through the long process of in-company training so vital to the performance needed later.

Our advice is: Hire the new and recent graduates—every one you possibly can. For by doing so, how can you possibly lose? You will need them in the future.

J.B.M.

#### **EDITORS NOTE**

CEP's readers are advised that certain minor inconsistencies in typography, page layout, etc., appearing in this issue are the result of our having changed printing plants in the interest of future efficiency and economy. In the complex structure of a magazine, errors and inconsistencies are always prone to occur, but particularly so when changing facilities.

J.B.M.

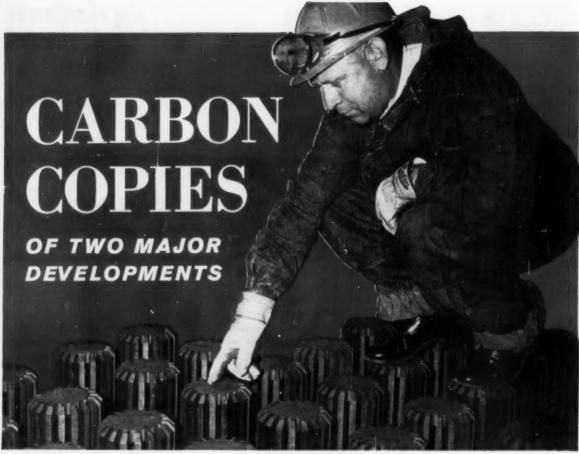


Photo Courtesy Bakelite Company



Do You Have These Engineering Bulletins?

Bulletins S-29, TP-54 and TA-30 contain helpful data on tower packings, tower support plates and distributors. Free on request.

Where packed columns were to operate at elevated temperatures (above 250°F-300°F) or with corrosives which attack ceramics, the engineer has been decidedly limited in his choice of tower packings and tower support plates.

Now, as a result of the joint efforts of The U. S. Stoneware Co. and the National Carbon Co., Intalox Saddle packing and "Gas-Injection Weir-type" Support plates are available in carbon—to function in that portion of the spectrum where metals and ceramics are unsatisfactory.

Because both the Intalox saddles and the Weir-type Support plates are all carbon—with no extractable binder—such diverse corrosives as alkalies, sulphuric, hydrochloric, phosphoric, hydrofluoric acids and hot dichlorbenzene offer no problem.

Now, in carbon, are all the advantages that characterize Ceramic Intalox Saddles: low pressure drop, high flooding limits, higher mass transfer coefficients, lower HTU. Now, in carbon, is a packing support plate that provides negligible pressure drop since it provides better than 50% free space under actual operating con-

ditions. These newer developments are just two more reasons why chemical engineers with problems in packed tower design, say—"Consult U. S. Stoneware first."



# hydrometallurgy

# its scope and limitations

In the field of metal production the two principal areas are pyrometallurgy, which comprises chiefly high temperature operations involving molten materials, and hydrometallurgy in which aqueous solutions are used at one or more stages in separating and recovering metals from naturally occurring minerals. The high temperature, so-called "fire" methods have been used since prehistoric times with, of course, the introduction of many refinements in recent years. For a number of reasons, "wet" methods have been developed only in comparatively recent times—principally during the last seventy-five years.

With a few notable exceptions—such as the production of copper and mercury metals by direct oxidation of the sulfides—pyrometal-lurgical processes are concerned with the treatment of solid oxides of the metals under conditions that provide selective oxidation or reduction. Because these processes for metal production and purification are conducted at high temperatures, they are usually characterized by high reaction rates: the separations that can be effected are largely determined (and restricted) by equilibrium relations between the liquid phases or liquid and gas phases. The best that can be expected is a compromise between the degree of oxidation or reduction that can be effected at a given temperature and the

F. A. Forward

Department of Mining and Metallurgy The University of British Columbia.

#### ... physical factors in hydrometallurgy and chemical industry differ

composition of the phases present. In certain refining operations, such as the recently developed zone melting procedure, it is possible to establish conditions that produce phenomenally

sharp phase separations.

Hydrometallurgical processes, on the other hand, are invariably concerned with the behavior of metal ions in aqueous solution. The operating temperatures are usually, but not necessarily, below the boiling point of water. Because solid, liquid and gas phases may all be involved in a given reaction, and because the temperatures are low, reaction rates tend to be low, equilibrium is less likely to be reached, and reaction kinetics play an extremely important role in determining the character and even the feasibility of a process. The successful conduct of a hydrometallurgical process thus requires a considerable knowledge of the behavior of metal ions in solution, of the solubility of gases. the character of reactions at gas-liquid and liquid-solid interfaces, of diffusion and transport, and indeed all the factors that comprise the study of reac-tion kinetics. The limitations, restrictions, and problems are vastly different from those met in pyrometallurgical processes: and because they are largely dynamic and transient phenomena, involving a time factor, they cannot be observed or recognized as readily as those involving principally equilibrium conditions. This dependence on advances in the knowledge of inorganic and physical chemistry accounts in large measure for the fact that hydrometallurgical methods have been developed only in recent times.

The growth of chemical engineering as a separate discipline during the present century has paralleled in some degree the developments in hydrometallurgy-possibly for similar reasons in that the operations usually considered to lie in this field involve a time factor, and require a comprehensive knowledge of the physical character and behavior of solids, liquids, and gases, of reaction kinetics and of physical chemistry. The contemporaneous and quasi-parallel development of chemical engineering and of hydrometallurgy has given rise to the popular belief that hydrometallurgy is a branch or species of chemical engineering. Despite the apparent similarity of the two there are a number of valid if not generally recognized reasons why this is not so.

One of the prime characteristics of the chemical industry is that the raw materials are relatively few in number and available in large quantities in numerous locations. A little reflection shows that the industry is based on such materials as air, water, limestone, coal, coke, salt, sulphur, natural gas, oil and cellulose, which though they may differ slightly according to their location or origin are nevertheless sufficiently uniform in composition that the chemical processes into which they enter are substantially the same throughout the world. The principal concern is not usually the specific composition of the raw material or the quantity available from a particular source but rather the location of the source, the cost of conversion to end products, of which there are many thousands, transportation of the products to market, and above all the extent and location of the market.

In the chemical industry the success of an operation depends very much upon the skill and ingenuity of the chemical engineer who must be constantly alert to ensure that costs are reduced, products improved, and new markets developed in a world in which his competitors have equal access to abundant raw materials. Of more than passing interest is the observation that the reactions taking place in chemical processes appear to be chiefly the con-cern of the research chemist rather than the chemical engineer, the activities of the latter being related more to physical operations-heat and mass transfer, absorption, distillation, evaporation, compression, phase separations-his interest in the so-called unit processes lying more in the means of carrying out oxidation, fermentation, polymerization, etc., than in the chem-

istry involved.

The metal production industry, with which hydrometallurgy is inseparably associated in both fact and principle, operates under economic and physical conditions that are diametrically opposite those in the chemical industry. The raw materials-minerals in situ-are legion in number and character but limited in amount and, therefore, expendable. The products, on the other hand, are few-steel ingots, lead, zinc, copper, aluminum, nickel, tin, etc.-commodities that meet a common standard and that have a world

market. In this industry the exploitation of a mineral deposit must take into account the capital expenditure that is justified in the economic processing of a finite amount of raw material in a specific period of time. The major profit is derived not from ingenuity in processing or market development but from owning the reserve of mineral in the ground. The success of the metal producer thus depends as much on exploration and the discovery of new deposits as it does on efficient processing, although it must not be overlooked that developments in chemical research and technology not only add to the profits available from a known mineral reserve but, indeed, make possible the exploitation of lower grade ores and thus increase the potentially economic mineral re-

The physical factors in metal production, and these are even more restrictive in hydrometallurgy than in high temperature operations, are, again, quite different from those encountered in the chemical industry. In the first place every mineral deposit is unique-the minerals present, their proportions and amount, the associated impurities, and the particle size differ greatly even in different parts of the same deposit. It is possible to predict with some confidence the behavior of an ore or concentrate in a smelting furnace or of an anode in an electrolytic refinery, but in hydrometallurgical operations each starting material will be different physically or chemically from every other and no responsible person would consider setting up a hydrometallurgical operation without having made exhaustive laboratory and pilot plant tests on the actual material to be treated.

Peculiarly enough, yet understandably, the hydrometallurgist is very much more concerned with the chemistry of the processes he employs than is his chemical engineering counterpart in the chemical industry. For each new starting material he must devise a specific series of chemical reactions that will effect the necessary separations with the least expenditure of energy, the maximum economic recovery of metals, the lowest reagent consumption and within the limit of capital expenditure justified by the amount of raw material available. Because all minerals are solids, he is concerned with the behavior (and

idiosyncrasies) of crystal forms, of diffusion in solids, of solid-liquid and solid-gas reactions and of the peculiarities of mineral particles and metallic surfaces. Like the chemical engineer the hydrometallurgist must use efficient physical procedures for carrying out the reactions involved in his operations-he, too, is interested in heat and mass transfer, absorption, phase separations, etc., but the success of a hydrometallurgical process is much more dependent upon an adequate knowledge of inorganic chemistry and the choice of a suitable sequence of reactions than it is upon the physical means employed to conduct them.

Hydrometallurgical processes usually comprise five main steps—preparation, dissolution, purification, precipi-



tation, and regeneration. One or the other of these may be omitted under exceptional circumstances or modifications may occasionally be necessary but the essential feature is that the valuable metals involved must be oxidized to ions, the various metal ions separated and the metals recovered separately by reduction of the ions or of a precipitate.

PREPARATION may involve physical or chemical treatment of the starting material to render it amenable to subsequent dissolution. Ores and artificial products such as mattes are usually crushed or ground for one or both of two purposes-(a) to permit access of the lixiviant to the minerals to be dissolved, (b) to increase the surface area and accelerate dissolution. Flotation is sometimes employed to remove unwanted impurities previous to leaching and thus reduce both reagent consumption and tonnage to be treated. Chemical preparation may include roasting to convert sulphides-zinc, for example-to oxides which are soluble in the leach solutions, or the crude materials may be smelted to effect concentration and convert the minerals to alloys or artificial sulphides which are then dissolved.

Dissolution, or leaching, which is essentially oxidative in character, may be carried out in an almost infinite variety of ways. The solutions may be acid or alkaline, organic or inorganic. dilute or concentrated, the operation being conducted at temperatures from room temperature to 500° F, with or without mechanical agitation, in open or closed vessels, at pressures from atmospheric to 600 lbs./sq. in., for periods of time varying from a few minutes to two weeks or even several months. The choice depends upon the chemistry involved, the availability and cost of equipment, the cost of labor, energy, and reagents, the value of the metals involved, and, often enough, upon the philosophy of management. Ordinarily, the objective is to select a lixiviant that is readily available, will selectively and rapidly dissolve the desired metals without corroding the leaching equipment unduly and that is either cheap enough that it can be discarded or, if costly, can be easily regenerated. For every starting material and every location there is an optimum combination of these conditions which the hydrometallurgist must strive to achieve.

PURIFICATION of the leach solutions involves separation (and often concentration) of the dissolved metals by chemical means to produce solutions having a composition of such character that the individual metals can be precipitated in a subsequent operation. Here again every operation is unique and no general rule can be established. In zinc leaching, for example, the zinc oxide, produced by roasting the sulphide ore, after leaching with dilute sulphuric acid to effect separation from ferric oxide produces a nearly neutral zinc sulphate solution containing small amounts of arsenic, antimony, copper, cobalt, and cadmium, each of which must be removed to very low limits by different chemical processes before the purified solution can be electrolyzed to produce zinc metal. If minute traces of germanium were present in the zinc ore, a much more complicated treatment would be required. Similarly the presence of chloride minerals in a copper ore requires the inclusion of a chloride removal step which is quite unnecessarv if only oxide minerals are present.

PRECIPITATION results in the production of a metal or of an insoluble oxidized compound which must be subsequently reduced to metal. The essential feature of this step is that energy must be supplied in at least the theoretical amount to convert the ions to metals. The kind and cost of



available energy and the efficiency of application represent major cost factors in hydrometallurgical processes that frequently determine whether or not such processes are economically feasible. The several ways of precipitating metals from solutions include electrolysis with insoluble anodes, cementation by addition of a more reactive metal to the solution, and the use of a reducing gas such as hydrogen or carbon monoxide under suitable conditions of temperature and pressure. Because water is present the difficulty of precipitating metals from solutions increases with the relative activity of a metal and its tendency to react with water. Metals less active than hydrogen are easily precipitated from acid or alkaline solutions: the upper limit of those more active than hydrogen is marked by zinc and manganese. Aluminum, uranium, rare earths and alkaline earths can be precipitated only as oxidized compounds which are subsequently reduced to metal by pyrometallurgical methods.

REGENERATION of leach solutions, with one or two exceptions, implies supplying to a cyclic system the energy required to oxidize and dissolve a subsequent charge of raw material. The exceptions are those processes in which the starting material is an oxide and the metal is precipitated from the leach solution as an oxidized compound of similar energy content as, for example, the dissolution of bauxite in caustic soda solutions, followed by hydrolytic precipitation of aluminum hydroxide with regeneration of the caustic soda. Whether or not to regenerate is determined by the cost of the leaching reagents, the cost and availability of

... three-phase heterogeneous reactions, ion exchange and solvent extractions; high temperature and high pressure techniques; oxygenation at super-atmospheric pressures; continuous and automatic operation

chemical or electrical energy, the possible accumulation of undesirable impurities, and even by the availability or otherwise of a suitable disposal area for spent solutions. Occasionally, as in the ammonia leaching of sulphide minerals where ammonium sulphate is formed, the product of leaching is a marketable commodity and regeneration (of ammonium) is unwarranted. In many instances, as, for example, the leaching of copper oxides or zinc oxides in sulphuric acid followed by electrolytic precipitation of the copper or zinc, the energy supplied for metal precipitation simultaneously regenerates the leaching agent-in this case sulphuric acid. Where this principle can be applied, it has many advantages over chemical precipitation with regeneration of the leach solution in a subsequent sepa-

rate operation. The technology of conventional hydrometallurgical operations is well known and needs no elaborationleaching in open tanks, mechanical and air agitation, thickening, filtration, evaporation, hydrolysis, crystallization, cementation, electrolysis, and other procedures are familiar throughout the metallurgical and chemical industries. Some of the procedures that have found application recently in hydrometallurgy do, however, warrant some comment. Of these the one that has developed the greatest interest and which gives promise of broadest application is the introduction of high temperature and high pressure techniques in the leaching, purification, precipitation, and regeneration steps. Although bauxite, scheelite and other oxides have been treated at elevated pressures for many years the operations involved represented only dissolution without oxidation. The newer procedures, which have been effectively demonstrated on a large scale in the treatment of primary uranium ores by Eldorado Mining and Refining Company, and of nickel-copper-cobalt-iron sulphides by Sherritt Gordon Mines Limited, involve the introduction and use of oxygen at super-atmospheric pressures as an oxidizing agent and in the case of nickel, copper, and cobalt the use of hydrogen as a reducing agent thus replacing chemical oxidants and electrolysis.

The versatility and potential advantages of high pressure processes can be attributed to two factors-first the higher reaction rates and second the shift in equilibrium conditions occasioned by higher temperatures. Volatile components and gases can be retained in closed vessels and thus gaseous reagents employed for both oxidation and reduction. Oxygen, hydrogen, carbon monoxide, ammonia, carbon dioxide, hydrogen sulphide, sulphur dioxide and other gases can be used over a much wider range of temperature and reactions carried out rapidly and efficiently to produce results that could not have been achieved had not the hydrometallurgist devised methods of breaking through the boundary of the boiling point of aqueous solutions and conducting economically the three-phase heterogeneous reactions so common in the field of metal production.

Two other procedures that have found particular application in uranium hydrometallurgy but which are being extended to other metals are ion exchange and solvent extraction. In the ion exchange operation dilute solutions of metals, uranium in this case, are passed through a column of coarse resin particles which selectively combine with the uranium ions and remove them from solution. The resin, when loaded, is treated with strong acid which detaches the uranium to form a concentrated solution of the appropriate salt and regenerates the resin for subsequent use by replacing the detached uranium ions with hy-drogen ions. The many variations in resin composition, the use of resin-inpulp techniques, and the specificity of ion selection make this technique most useful in ion separation, although the capital cost of resin, the rather light maximum loading, and the difficulties encountered with attrition and poisoning have, so far, restricted its use to valuable metals such as uranium, rare earths, etc., in low concentrations where the concentration and separations effected by the procedure are valuable assets.

Solvent extraction, which has also been used effectively in uranium ore treatment, involves adding to the leach solutions an organic solvent which is substantially insoluble in water and

which at the same time complexes and dissolves the uranium. The procedures have the advantage that they can be operated continuously and automatically in a multiplicity of stages and that the uranium is concentrated in the solvent from which it can be extracted by basic or acid aqueous solutions, the solvent being regenerated. There is a prospect also that solvent extraction, like the resin-in-pulp ion exchange technique, can be used to extract uranium from pulps thus avoid-ing the liquid-solid separation problem that is often difficult, especially in the presence of semi-colloidal solid particles. With the development of suitable solvents it is possible that solvent extraction may be extended to other base metals but, for the present, the cost of solvents, their limited range of composition, and mechanical losses incurred restrict the application to metals of higher unit

The applications of hydrometallurgical processes in the production of aluminum, zinc, nickel, uranium, and gold provide useful illustrations of the principles and techniques described

Aluminum is the simplest of these operations in that it comprises only dissolution of a hydrated oxide, bauxite, in a concentrated caustic soda solution at about 160°C to form soluble sodium aluminate (and other sodium compounds), leaving iron, silica, and some alumina as insoluble residues which are separated from the aluminate solution by filtration. The solution is cooled and hydrolyzed under controlled conditions in the presence of aluminum hydroxide "seed" to produce pure aluminum hydroxide and regenerate caustic soda. The pure hydroxide is calcined to oxide which is subsequently reduced in an electrolytic cell. Some of the principal difficulties encountered in the hydrometallurgy of aluminum are the dissolution of silica as sodium silicate, and of titanium and other impurities which require that particular care be taken in hydrolysis to prevent coprecipitation and to produce a highpurity aluminum hydroxide. Filtration and washing of the semi-colloidal materials involved constitutes a serious but not insurmountable difficulty.

Zinc leaching presents a different problem. The ores, containing zinc, iron, lead, copper, cadmium, cobalt, arsenic, antimony, and precious metals are sulphides which must be roasted, principally to convert the zinc to oxide, although the other base metals present are also converted to oxides at the same time. The mixture of oxides is leached with dilute sulphuric acid, usually in a two-stage counter-current operation which results in the dissolution of zinc, copper, cadmium, cobalt, and small amounts of iron, antimony and arsenic all as sulphates: the iron oxide, lead, silica, precious metals, etc., remain undissolved and can be recovered, if desired, by subsequent pyrometallurgical operations. The zinc sulphate solution, with impurities, is adjusted with respect to pH and ferric iron content to effect oxidation and hydrolysis of iron, arsenic, and antimony, which are removed: the filtrate is then neutralized with excess zinc oxide to remove the remaining impurities except cop-per, cadmium and cobalt. The copper and cadmium are removed as cemented metals by adding zinc dust, and cobalt by adding a-nitroso-B -naphthol-a specific precipitant.

The purified zinc sulphate solution is then electrolyzed in a bath with lead anodes and aluminum cathodes, the zinc being precipitated on and stripped from the latter. The spent electrolyte containing the sulphuric acid generated by electrolysis is returned to dissolve a new charge of roasted sulphides.

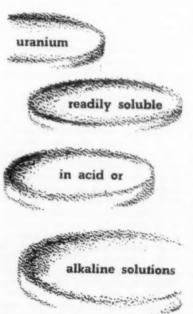
The nickel-bearing materials that are treated by hydrometallurgical processes are of three types—nickel oxides, nickel sulphides, and nickel alloys—each of which requires a different treatment.

The nickel oxides (laterites containing about 1.5% Ni and 45% Fe) are selectively reduced to form nickel metal and convert the iron oxides to magnetite. The reduced product is leached with an ammonia-ammonium carbonate solution in the presence of oxygen (air) to form soluble nickel amines, leaving the iron and other impurities in an insoluble residue. The leach solution is flash boiled to remove NH3 and CO2 thus causing the nickel to hydrolyze and precipitate as basic carbonate, which is either calcined to oxide and sold in that form or reduced to metal by separate procedures. The NH3 and CO2 are combined to regenerate the leach solution.

Another method of treating laterites comprises mixing the ore with dilute sulphuric acid, heating under pressure

to 500°F which dissolves the nickel. cobalt, and a small amount of iron as sulphates, leaving most of the iron as a basic sulphate which is formed as an insoluble compound at the high tem-perature used. The nickel and cobalt are preferentially precipitated as sulphides from the leach solution by the introduction of H2S at suitable temperature and pressure. The nickelcobalt sulphide is then redissolved by oxidation with air in an aqueous solution at high temperature and pressure to produce the corresponding sulphates which are further treated by ammoniation, evaporation, and hydrogen-reduction at high pressure to produce pure nickel and cobalt metals.

In an operation where the starting material is a nickel, copper, cobalt, iron sulphide mixture, the mixed sulphides are leached with an ammoniaammonium sulphate solution at elevated temperature and pressure (160°F and 100 psig) in the presence of compressed air. The copper, nickel and cobalt dissolve as amines, the sulphur forms thionates and sulphates, and the iron is quantitatively separated as ferric hydroxide. Boiling the leach solution drives off free ammonia, reduces the pH and promotes de-composition of the thionates with evolution of sulphide ions, which react with copper ions present to form insoluble copper sulphide which is removed leaving nickel and cobalt amines and ammonium sulphate. The amine solution is treated with hydrogen at 350°F to precipitate selectively



pure nickel metal. The small amount of residual nickel and the cobalt are separated as sulphides and the end solution evaporated to produce ammonium sulphate fertilizer. The nickel, cobalt, and copper sulphide by-products are further treated by similar procedures to separate and recover these metals.

Nickel alloys and mattes can be treated by converting them to soluble sulphates in an acid solution, ammoniating and proceeding by one or the other of the methods described or suitable variations of them.

Uranium, like nickel, has the advantage that it is readily soluble in acid or alkaline solutions. Carnotites dissolve without oxidation but primary uranium minerals such as pitchblende must be oxidized from the U<sup>4+</sup> to the U<sup>6+</sup> form to permit dissolution. The uranium minerals are so numerous and their modes of occurrence so varied that a wide variety of procedures has been developed.

Ores having acidic gangues, such as quartz, are usually treated by acid processes in which the lixiviant is sulphuric acid, with compressed air, or chemical oxidants such as sodium chlorate being used if primary (U4+) minerals are present. After separating the insoluble residues the uranyl sulphate solution is commonly treated by ion exchange or solvent extraction techniques to remove the uranium which is eluted from the resin or solvent to give a concentrated uranium solution from which a high-grade uranate is precipitated by chemical means. The older methods which involved precipitating uranium com-pounds directly from the dilute leach solutions by addition of metal powders, MgO, etc., have been largely superseded.

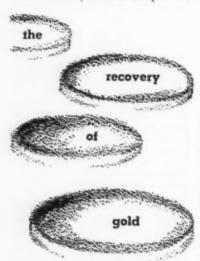
Due to the uneconomic consumption of acid, ores having a high content of limestone are not treated by acid leaching. Instead the lixiviant is a solution of sodium or ammonium carbonate and bicarbonate which, again, must be used in conjunction with air at atmospheric or elevated pressure or a chemical oxidant if primary uranium minerals are present. After separation of the insoluble residue uranium is present in solution as a uranyl carbonate complex. As ion exchange and solvent extraction methods have not yet been fully developed for use in basic media other procedures must be employed. One consists of increasing the hydroxyl ion content of the leach solution by addition of caustic soda causing the uranium to hydrolyze and precipitate as a sodium ura-

#### ... hydrometallurgy is unique for each raw material

nate. Another useful procedure comprises heating the solution to 300° F under hydrogen pressure in the presence of a metallic nickel catalyst which precipitates  $\mathrm{UO}_2$  and regenerates the bicarbonate content of the leach solution.

Vanadium, often present in uranium ores, complicates the chemical reactions involved in leaching and necessitates additional steps either before or after leaching to effect a suitable recovery and separation.

The recovery of gold by cyanidation is one of the oldest, (70 years), and in some ways the simplest, of hydrometallurgical processes. The process depends for its success on the fact that sodium cyanide in the presence



of dissolved oxygen in a basic aqueous solution dissolves gold and silver readily and efficiently to form complex cyanides. Upon separation of the undissolved residues the solution, after de-aeration is treated with metallic zinc or aluminum which precipitates the gold (and silver) as metals, the cyanide solution being returned to the leaching circuit. There are, of course, problems associated with the presence of easily oxidizable sulphides such as pyrrhotite (FeS) which tend to form thionates in the weakly basic leach solutions and which by consuming oxygen tend to inhibit gold dissolution; or the presence in an ore of copper and antimony minerals which react with cyanide and not only reduce the concentration of free cyanide but form complexes with it and thus increase reagent cost; or the gold may

be present in such finely divided form that it is occluded by sulphides necessitating a roasting step to convert the dense sulphides to porous oxides which permit the cyanide solution to gain access to the fine gold particles; about the worst situation is to have very fine gold occurring in a sulphide ore which contains, in addition to other minerals, appreciable amounts of lead and antimony sulphides which, on roasting to open up the iron sulphides, are converted to fusible insoluble oxides that effectively occlude the gold particles and completely prevent their dissolution in cvanide.

Despite these difficulties, however, it is not uncommon in the cyanidation of gold ores to produce a tailing containing only 0.01 oz. Au per ton from an ore containing say .30 oz. per ton. Thus this unique, well-tried, and not too well-understood hydrometallurgical process is capable of reacting with a metal (gold) in an ore where its concentration is 1:100,000 and extracting it cheaply and efficiently to the point where the residue contains (at .01 oz.) only 1 part in 3,000,000!

In summary it is emphasized that hydrometallurgy differs fundamentally from the chemical industry: it is analytic rather than synthetic in character, it is more concerned with the chemistry of operations than with physical procedures, the raw materials are expendable and irreplaceable, every plant and process is unique in that it is adapted to a specific starting material, and the profits are derived from the sale of an expendable resource rather than from the ingenuity of the process used or the quality or type of the product sold.

Thus it would appear that anyone in the chemical industry who contemplates entering the metallurgical field through hydrometallurgy which, in its operating procedures closely resembles many chemical processes and would therefore be a first choice for a chemical engineer, should realize that the prospect of making large profits is remote unless he is aware of the philosophic and economic features of the mineral industry and, in effect, unless he owns a reserve of mineral large enough and rich enough to justify exploitation.

Hydrometallurgical processes are efficient at present and with the introduction of more of the recognized chemical engineering techniques will become more so but they will always be subject to limitation by the perversity and peculiarities of solids, liquids, and gases in heterogeneous systems and to the restrictions inherent not only in thermodynamic equilibria but to reaction kinetics and the inescapable economic and physical factor—time!

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# the extraction of Tantalum and Columbium

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T ANTALUM AND COLUMBIUM, although discovered early in the nineteenth century, were not produced as pure metals until after the turn of the century. The unusual chemical properties and remarkable similarity of these elements contributed largely to the delay in their extraction from their not too familiar minerals. Both metals are resistant to chemical attack at ordinary temperatures but are soluble in hydrofluoric acid and quite reactive

to all common gases at elevated temperatures. The hydrated oxides react readily with hydrofluoric acid to form the pentafluorides and with potassium hydroxide to form potassium salts both of which are soluble in water.

Tantalum and columbium do not occur in the free state in nature. They are almost invariably found together in a number of oxide minerals, the most important of which are tantalite and columbite. These minerals are

variations of the same natural compound whose ideal formula is (Fe, Mn) (Ta, Cb)<sub>2</sub>O<sub>6</sub>. Tantalite-columbite occurs in some pegmatite dikes in quantities of 2 to 4 lb./ton and in alluvium of pegmatitic origin. Beneficiation is accomplished by the usual methods which include electrostatic and electromagnetic separation, jigging, and tabling. Alluvial deposits which are being worked for tin often yield columbite as a valuable byproduct.

The metallurgical extraction of tantalum and columbium begins with the mineral concentrates which contain between 60 and 80% mixed tantalum and columbium oxides of which from 5 to 75% is Ta<sub>2</sub>O<sub>5</sub>. The steps involved in the manufacture of these pure refractory metals are: (1) chemical extraction of the tantalum and columbium as mixed hydrated oxides, (2) chemical separation of the two elements and preparation of their pure compounds, (3) reduction of these pure compounds to metal powders, and (4) conversion of the metal powders to ductile bars.

#### Chemical extraction from ore

The ore concentrates are pulverized in a hammer mill or ball mill to facilitate subsequent chemical treatment. The powdered ore is fused with sodium hydroxide in an iron pot or tube to convert the earth oxides to sodium tantalate and columbate and the iron and manganese to hydroxides. The reaction takes place at a red heat and, when fine ore is used, is complete in a matter of seconds.

Other methods of "opening up" the ore are heating the fine concentrate with

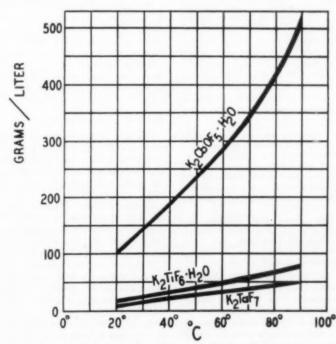


Fig. 1. Solubilities of double fluorides in 1 N hydrofluoric acid.

#### . Many variations in basic process

98% sulfuric acid or with 70% hydrofluoric acid. Both methods require more reaction time for complete decomposition and present difficult equipment problems.

The fused alkali-ore mixture is poured onto a chilled drum flaker and the flaked product is leached in water. The slurry is boiled with muriatic acid in a rubberlined vessel to dissolve the iron and manganese and to convert the sodium salts of tantalum and columbium to the hydrated oxides. The iron, manganese, and sodium chlorides are removed by decantation and washing with dilute acid. The resulting slurry contains the tantalum and columbium contaminated with small amounts of titanium, tin, zirconium, silicon, manganese, and iron.

## Separation of tantalum from columbium

A. By Crystallization of the Complex Fluorides. In 1866, about 65 years after the discovery of columbium by Charles Hatchett, Marignac made a very important contribution to the chemistry of tantalum and columbium when he described a method for the separation of the elements which took advantage of the difference in solubilities of K<sub>2</sub>TaF<sub>1</sub> and K<sub>2</sub>CbOF<sub>5</sub>. This classical method is still used in the manufacture of these metals (Figure 1).

In practice the slurry containing the hydrated metal oxides is dissolved in 70% hydrofluoric acid, diluted, and heated to near boiling. Potassium, as fluoride, carbonate, or hydroxide is added in sufficient quantity to form the double fluorides of the tantalum and columbium present. The solution is filtered and allowed to cool. At room temperature most of the tantalum salt is crystallized while the columbium remains in solution, the solubility of the columbium salt being about twelve times that of the tantalum salt. Recrystallized K<sub>2</sub>TaF: has the following typical analysis:

		1	Per Cent
Ta	*********		45.5
Si	Less	than	0.50
Fe	******	10	0.01
Ti	******	29	0.05
Cb		59	0.05

The mother liquor which contains the columbium and small amounts of tantalum and other ore residuals is treated to purify the columbium and to recover the remaining tantalum. Simple crystallization lowers the tantalum content of the mother liquor, based on the Cb<sub>2</sub>O<sub>8</sub> contained to less than 0.20% Ta<sub>3</sub>O<sub>4</sub>.

Further purification of the columbium is accomplished by crystallization of potassium columbate. To form the columbate, the columbium liquor (after removal of tantalum) is treated with an excess of sodium hydroxide to form the insoluble sodium columbate which is

converted to columbic acid with hydrochloric acid. The columbic acid slurry is dissolved in potassium hydroxide to form potassium columbate which is purified by fractional crystallization.

The potassium columbate after recrystallization is converted to pure hydrated Cb<sub>2</sub>O<sub>6</sub> by precipitation in hydrochloric acid. The hydrated oxide is filtered and ignited to Cb<sub>2</sub>O<sub>5</sub>. The composition of the oxide is as follows:

Cb <sub>2</sub> O <sub>3</sub>								×	99.7% min.	
Ta <sub>2</sub> O <sub>5</sub>				*		×			0.15% max.	
SiO <sub>2</sub>									0.05% max.	
TiO:			6					6	0.05% max.	
Fe <sub>2</sub> O <sub>2</sub>	75	×		*		*	*	8	0.05% max.	
ZrO:	*				*				0.10% max.	

B. By Liquid-Liquid Extraction. A recent method used for the production of pure tantalum and columbium compounds is liquid-liquid extraction. This method, investigated at the U. S. Bureau of Mines, has attracted the attention of all who are interested in the preparation of pure tantalum and columbium (1).

Many variations of the basic process have resulted from the efforts of several independent investigators.

The basic principles involve the effect of acidity on the solubility of the fluorides of Ta, Cb, Ti, Zr and Fe in methyl isobutyl ketone. When an aqueous solution of a mixture of these fluorides is brought in contact with MIBK, the tantalum is taken up by the organic phase at low acidity and the columbium at a higher acidity. Under these conditions the others tend to remain in the aqueous phase. The differences in solubilities are sufficient to give clean extractions of pure tantalum and pure columbium from impure solutions in only a few contacts or stages.

The separation may be accomplished by either of the following procedures.

1. First extract the tantalum by contacting a low acidity aqueous feed with ketone and then after increasing the acidity of the tantalum-free aqueous feed extract the columbium with fresh ketone, or . . . (Figure 2)

2. First extract both tantalum and columbium in the ketone from a strongly acidic aqueous feed and then back-extract the columbium from the organic phase with dilute acid. (Figure 3)

In any case, the metal values are recovered from the organic phase by back-extracting to a lower acidity aqueous phase and converting the fluorides to hydrated oxides by precipitation with ammonia or to the double fluorides by the addition of KF.

The equipment consists of: (1) rubber or polyethylene-lined tanks to dissolve the crude mixed oxides to form the fluoride feed solution, (2) polyethylene-countercurrent towers or mixer-settler cells for contacting the organic and aqueous liquids, and (3) rubber- or polyethylene-lined tanks for converting the separated fluorides to hydrated oxides.

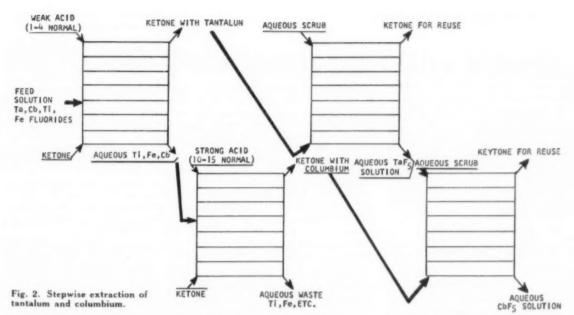
C. By Ion Exchange. Ion exchange methods are not new to chemical industry but have been applied only recently to the extraction of tantalum and columbium from fluoride solutions. The U.S. Bureau of Standards investigated ion exchange methods for the analyses of tantalum and columbium ores and one such procedure is used presently in analytical chemistry for the evaluation of these ores. The application of ion exchange methods for the industrial separation of tantalum and columbium will depend on economic considerations. At present, liquid-liquid methods appear to be favored over ion exchange methods because: 1) The ratio of metal to reagent is higher in liquid-liquid. 2) Liquid-liquid lends itself better to continuous operation (2).

## Reduction of tantalum and columbium

Methods employed in the reduction of tantalum and columbium compounds make use of modern techniques. Both metals are produced by powder metallurgy and in general all reduction methods apply to either metal. The choice of method depends on individual requirements and economic considerations.

#### Reduction by carbon

The first recorded attempt to produce metallic tantalum was by the reduction of the oxide with carbon. The product was a hard brittle material which was probably mostly tantalum carbide. However, some fifty vears later in 1935 a modification of this method was used by C. W. Balke to produce pure tantalum and columbium metals. (3) The method consists of first, preparing the carbide, TaC or CbC, by reacting stoichiometric quantities of the oxide with lampblack at about 2000°C. in a graphite container, and then reacting a mixture of the carbide with the proper amount of oxide at about the same temperature in a vacuum to form the metal. In the second operation, the mixture of car-



bide and oxide is pressed into bars which are heated in vacuum by radiation from graphite or tantalum resistance elements. The result is a porous mass of metal containing small amounts of oxygen and carbon which are removed during subsequent sintering operations. This method is used currently in the manufacture of columbium. Sintered columbium metal has the following typical analysis:

										%
Cb				0	0	0	0			99.8
Ta					-	×		*	×	0.05
Ti			0		0		0			0.01
Fe			0		۰		0	0	0	0.01
$0_{i}$				0			0		0	0.05
N.							0	0		0.03
C										0.02

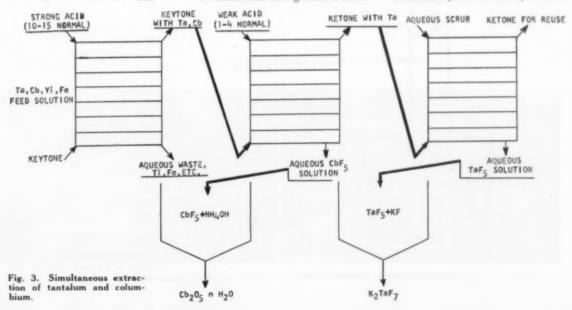
#### Reduction by sodium

The first successful attempt to produce pure ductile tantalum was made by von Bolton in Germany in 1903. He made tantalum powder by the thermal reduction of potassium fluotantalate with sodium. This method which is still in use is accomplished by sealing a mixture of K, TaF, and sodium pellets in a steel container and heating the container to about 700°C. in a muffle furnace. At this temperature the reaction which is exothermic proceeds rapidly. The "bomb" is cooled and the metal-salt mass is crushed and leached with water to recover the metal. The powder slurry is washed with strong acids to remove

the residual salt and surface impurities. This method produces a relatively fine powder which is notably free from carbon but contains a small amount of oxygen

# Electrolysis of potassium fluotantalate

Production of tantalum by the electrolysis of fused  $K_2TaF_\tau$  has been continuous since 1922. More pure tantalum powder has been made by this method than by any other. The cell consists of a sturdy graphite anode and an iron pot which acts as a cathode. The electrolyte is pure  $K_2TaF_\tau$  which is heated to about 900°C. Tantalum oxide (or other oxides) is added



#### ... New and novel method

occasionally to the bath to depolarize the anode surface. The cell is batch operated until the accumulated powder mass almost fills the pot. (Figure 4). Then the current is interrupted and the pot allowed to cool to room temperature. The melt is removed from the pot, crushed, and pulverized to detach the salt from the metal powder particles. The metal is recovered by tabling and washing with strong acids. Typical analysis of tantalum powder produced by electrolysis is:

		%
Ta		99.85
Cb	Less than	0.05
C		0.12
Fe	*********	0.015
Ti	Less than	0.01
	MESH ANALYSIS	
30%	+200	mesh
	200	
	+400	
200	_400	

Advantages of the electrolysis method are: 1) The powder is relatively coarse and, therefore, easily washed free from harmful impurities. 2) Its ductility, particle size, and purity are well suited to compacting and sintering.

The disadvantages are: 1) High equipment cost, and 2) Low yields. Less than 50% of the tantalum is reduced during the operation of the cell. The unreduced salt must be recovered

by leaching and recrystallizing.

A variation of the electrolysis method employs a cell composed of a heated graphite pot and removable metal cathodes. The electrolyte is a fused alkali chloride to which  $K_2TaF_7$  is added. The operation of the cell is more or less continuous since the metal cathodes, when loaded with deposited metal, are removed and quickly replaced with others. The metal content of the bath is replenished by adding  $K_2TaF_7$ .

## Decomposition of Al<sub>3</sub>Ta by copper

A new and novel method for the production of tantalum employs the chemical decomposition of the compound, Al, Ta, by copper (4).

When  $K_2TaF_7$  and an excess of aluminum metal are heated together at about  $1100^\circ$  C., the tantalum is quantitatively converted to  $Al_aTa$ . The reaction is carried out in a graphite crucible which is heated by induction. The  $Al_3Ta$  is a stable granular powder and is recovered easily by dissolving the aluminum matrix in acid. If the clean, dry  $Al_3Ta$  powder is heated to above  $1100^\circ$  C. with copper, the tantalum is freed and remains suspended in an alloy of aluminum and copper. This reaction like the first one, also is quantitative. The tantalum pow-

der is recovered by dissolving the aluminum copper alloy in acid.

In practice the two reactions are accomplished in successive steps in the same equipment.

The K<sub>2</sub>TaF<sub>7</sub> and aluminum are heated together in the graphite crucible to form the Al<sub>3</sub>Ta suspended in the excess of aluminum with a protective slag of potassium aluminum fluoride on the surface. The corrosive fluoride slag is decanted and replaced by a sodium-potassium chloride slag. At this point, copper is added to the melt to complete the conversion to tantalum metal and then the melt is cast into molds to cool. The tantalum powder is recovered by solution of the Al-Cu allov in acid.

The tantalum powder produced in this way is generally finer and has a more uniform particle size than that produced by electrolysis but is coarser than sodium reduced metal. It contains small quantities of carbon, aluminum, and copper as residual impurities which are removed during subsequent sintering operations.

The important advantages of this method are high yields and low equipment costs. A disadvantage is the necessity to recover fairly large quantities of copper which are used in the process.

#### Other methods of reduction

Several other methods for the reduction of tantalum and columbium have been investigated and a few are worthy of mention.

The Kroll process (decomposition of the halide with magnesium) has been examined but the conversion of the "sponge" to high purity, ductile metal is somewhat difficult.

The Van Arkle method (decomposition of a halide by a hot wire) produces high quality metal but the cost of this method is comparatively high.

Powell and Campbell at Battelle have "vapor plated" tantalum on other metal objects by heating them to about 1100° C. in a stream of TaCl<sub>5</sub> and hydrogen. However, the coatings produced thus far have been somewhat porous and lacking in ductility.

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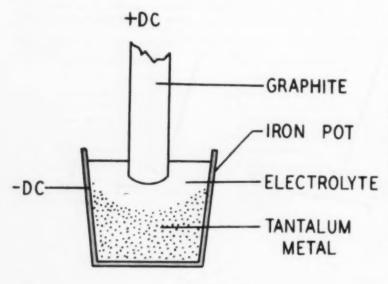


Fig. 4. Tantalum electrolysis cell.

# **BERYLLIUM:** a continuous extractive process

Kenneth B. Higbie<sup>1</sup>

and Max C. Farmer<sup>2</sup>

NTEREST IN BERYLLIUM METAL and metal allovs has skyrocketed in the past few years. The Atomic Energy Commission has been the stimulus of a new industry which will be producing large quantities of the pure metal for nuclear applications. Aircraft industries have shown more than casual interest in the pure metal for structural applications in the planes of the future. The addition of beryllium to the present family of structural materials has been forecast.1 The use of beryllium copper alloys continues to expand to new applications requiring high strength, rigidity or electrical conductivity. Other beryllium alloys, such as beryllium nickel and beryllium aluminum are finding increased markets. Alloy production will be the highest ever during 1957.

As a natural result of the increasing need for products containing beryl-

lium, the knowledge of beryllium metallurgical processes is rapidly expanding. This paper pertains to the extractive metallurgical processes employed at The Beryllium Corporation and the subsequent reduction of beryllium oxide to beryllium copper master alloy. Details concerning the health aspects of the beryllium industry have not been enumerated. The Beryllium Corporation has in operation an extensive program aimed to meet its responsibility in the area of industrial hygiene. The metallurgical process, as described herein, has been reduced to its basic aspects in order to provide for a more uniform flow and, therefore, allow for greater understanding of the fundamentals involved. An excellent accounting of beryllium health hazards has been reported.2

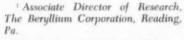
Beryllium is known to exist in over 30 different minerals. The primary commercial source of the metal is the mineral beryl, a beryllium-aluminum silicate with a theoretical formula 3BeO.Al, O3.6SiO2. This is fundamentally the same chemical composition as emerald and aquamarine. The theoretical quantity of beryllium oxide in the beryl crystal is 13.9% by weight. Beryl occurs in pegmatites and granites throughout the world, but is presently recovered economically from only the pegmatites. To be recovered, beryl must be in crystals large enough to permit hand cobbing (hand sorting). Beryl is found in crystal form, many of which are as large as 18" in diameter. In the United States minimum recoverable crystal size is

limited to about 1" in diameter, but cheaper labor in foreign countries permits recovery of crystals as small as %". Although progress is being made, mechanical methods for concentrating beryl have not been perfected for industrial use. The mineral is found in various areas of the world. According to Bureau of Mines Statistics, the main producing countries in 1955 were: Brazil 20.8%, Argentina 17.1%, Southern Rhodesia 11.1%, Mozambique 11.0%, India 9.7%, United States 5.7%, and the remainder of the free world 24.6%.

Processes for the extraction of the valuable metal from beryl have been proposed by many investigators,6 but because of the relative inertness of the mineral to attack by either acids or alkalies at low temperatures except for hydrofluoric acid, very few of the methods are considered feasible for industrial adaptation. The Beryllium Corporation employs a modification of the Copaux-Kawecki process using beryl ore concentrates containing from 8-12.5% BeO. High grade concentrates are desired since continuous processing of concentrates containing less than 10% BeO would require equipment modifications of indeterminate magnitude.

#### Preparation of ore

Figure 1 is a flow sheet showing the various phases of the extractive process. The initial step in the process is the crushing of beryl crystals in a jaw crusher to an average particle size of %". The crushed product is then fed to a Hardinge conical ball mill with



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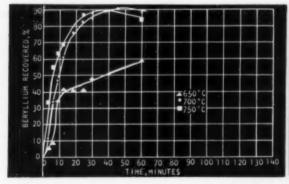


Figure 2. Time at sinter temperature vs. Be recovered.

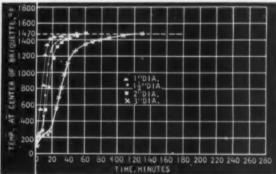
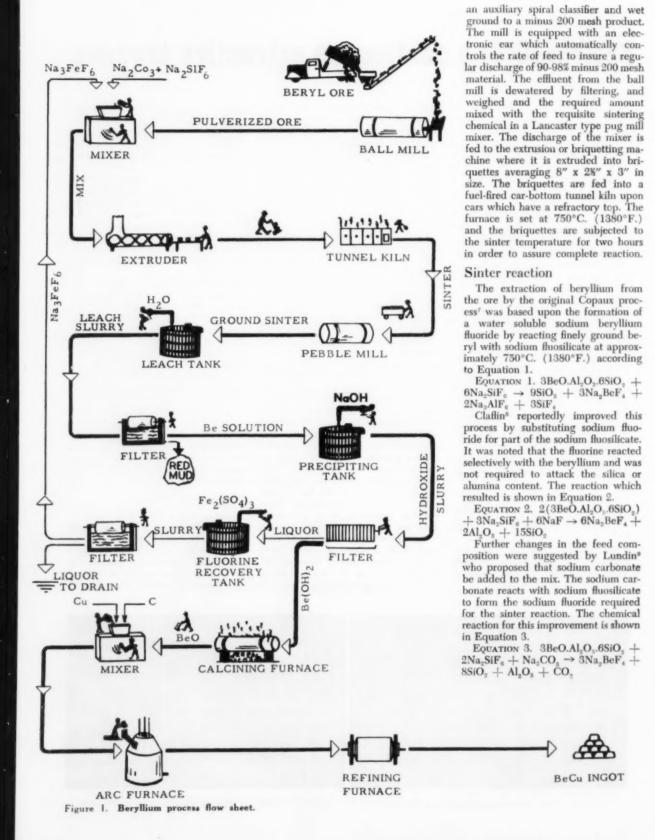


Figure 3. Time vs. temperature at center of briquette.



#### . . . Sintering necessary to effect chemical reaction

Kawecki<sup>10</sup> suggested a further change in the process as shown in Equation 4, to include the addition of sodium ferric fluoride or iron cryolite. Much of the fluorine in the system could be recovered later as iron cryolite and recycled for further use at a substantial savings in cost.

Equation 4.  ${}^{3}\text{BeO.Al}_{2}\text{O}_{3}.6\text{SiO}_{2} + 2\text{Na}_{3}\text{FeF}_{6} \rightarrow 3\text{Na}_{2}\text{BeF}_{4} + \text{Fe}_{2}\text{O}_{3} + 4\text{SiO}_{2} + 6\text{SiO}_{2}$ 

As the economy and availability of the various fluoride containing salts vary, combinations of Equations 1, 2, 3 and 4 can be utilized as a sinter mix. It must be recognized, however, that excess amounts of these various salts must be limited. If a great excess of sodium carbonate or sodium silica fluoride is used, water soluble sodium silicate, Na<sub>2</sub>SiO<sub>4</sub>, results which will be subsequently precipitated with and contaminate the valuable beryllium.

The object of the sintering step is to effect a chemical reaction and produce a uniform physical structure which is amenable to further chemical processing. The efficiency of the sinter reaction is based not only upon the quantity of associated chemicals added, but also upon the sinter temperature, time at temperature, density of extrusion, and size of extrusion. Excess temperature results in a fusion of the sinter mix, excess time at high temperatures also tends to fuse the mix, nonuniformity of density of the extruded mix will cause a variation in heat transfer, and if the density variation is extreme, the extruded briquettes will tend to break apart once again resulting in nonuniformity of the reaction at the sinter temperature. If the speed through the furnace is too high, the center of the briquette does not come to temperature and the reaction is incomplete. Not only does the efficiency of the extraction of beryllium drop off, but the unreactive silica-containing

salts are dissolved with the sodium beryllium fluoride and an impure product is obtained. Figure 2 plots the sintering temperature versus removal of water soluble beryllium. A sinter temperature of 700°C. (1292° F.) is indicated as the optimum temperature for the laboratory experiments. Above this point the sinter mass tended to fuse and leaching efficiency decreased. Below the optimum temperature the reaction was incomplete with a resultant decrease in leaching efficiency. The residence time was related to the diameter of the sample. The heat penetrates 1 to 1% inches in a relatively short period of time, but the curve is not lineal and excess time is required as the diameter increases. This is illustrated in Figure 3. The static condition encountered in the production equipment requires that a slightly higher temperature of 750°C. be maintained for maximum extraction efficiency.

The sintered briquettes are fed to a jaw crusher and reduced to approximately % inch in size. The ground sinter then is fed to a Hardinge conical pebble mill where it is wet ground to 98% minus 200 mesh. The oversize is returned for grinding by a special type counter current classifier. The discharge from the pebble mill is pumped to the leach tanks where the sinter is leached and the liquor decanted three times with room temperature water. Successive decantations contain 3-5 g/l, 2-3 g/l, and 0.5-1.5 g/l of soluble beryllium calculated as beryllium oxide. The three liquors are combined into one and sent on to the precipitation tanks. The final slurry is filtered on an Oliver rotary filter and the insoluble "red mud" washed to remove all valuable metal. The final red mud contains about 0.3% water soluble beryllium. If the sinter is added to leach water while hot, the

liquor tends to become excessively warm and impurities, such as silica and iron, increase by virtue of the tendency for colloidal particles to disperse more easily in warm liquors.

The beryllium contained in the liquors as sodium beryllium fluoride is recovered as beryllium hydroxide by addition of a 50% caustic solution. In order to recover a granular hydroxide, the requisite amount of caustic for precipitation of a complete tankful of liquor is first added to about 20% of the total volume of liquor. This caustic precipitates the beryllium from the liquor already in the tank and then redissolves it to form a sodium berylate as shown in Equation 5.

Equation 5.  $Na_2BeF_4 + 2NaOH \rightarrow Excess$  $Be(OH)_2 + 4NaF \xrightarrow{Excess} Na_2BeO_2$ 

 $+4NaF + 2H_{\bullet}O$ 

The solution is heated to near boiling and additional liquor, preferably of the same beryllium content, is then pumped to the precipitation tank maintaining the high temperature and bringing the total level of liquor up to the required volume. The liquor is then tested for complete precipitation. During the reaction there is continued the initial precipitation of Be(OH), the resolution of sodium berylate, and subsequent reprecipitation of beryllium hydroxide as a granular product. The final product is recovered by filtration in a Shriever plate and frame filter. The liquors are sent to storage for subsequent recovery of the fluorine content as iron cryolite. The filter cake is washed with hot water, air blown and delivered to gasfired rotary calciners set at 850°C. (1600°F.). In Figure 4 the calcining temperature of beryllium hydroxide is plotted against the loss in weight. Experimental evidence indicated that a temperature of 400°C. (752°F.) was

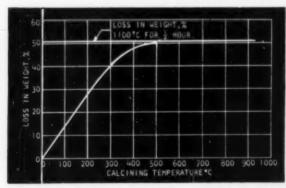


Figure 4. Be (OH)2 calcined 20 hr. at varying temperature.

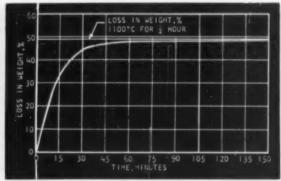


Figure 5. Be (OH): calcined at 400 C.

required to convert the hydroxide to beryllium oxide and reduce the moisture content to less than 3%. The sample which was studied in the laboratory contained about 50% moisture, and was considered to be in excess of the standard plant product which is, on the average, 20% moisture. Figure 5 indicates that a residence period of 45 minutes was required to bring the sample to essentially a constant weight. Other samples containing more or less moisture also attained the same degree of dryness in 45 minutes, thus indicating that additional time would not be required if a high moisture batch of hydroxide was accidentally produced. In actual practice it was found that the calciners could not completely remove the moisture because of increased mass size and a decrease in heat transfer. Therefore, the temperature was raised to 850°C. and a residence period of 20 minutes was provided for. This resulted in an oxide product which averages less than 3 percent moisture content. The final oxide is then ready for the processing in the arc furnace for reduction to beryllium copper master alloy. The sodium fluoride filtrate which was sent to storage is acidified to a pH of about 4.0 with sulfuric acid and a 30 percent ferric sulfate solution is slowly added in order to precipitate the solu-ble sodium fluoride as sodium ferric fluoride or iron cryolite.

EQUATION 6.  $12\text{NaF} + \text{Fe}_2(\text{SO}_4)_3$  $\rightarrow 2\text{Na}_3\text{FeF}_6 + 3\text{Na}_2\text{SO}_4$ 

The precipitate is recovered in a Shriver plate and frame filter and recycled for mixing with ore as previously described.

# Production of beryllium copper master alloy

Beryllium copper master alloy is produced in a three phase carbon electrode vertical, arc-type reduction furnace. The alloy is obtained during the thermal reduction of beryllium oxide with carbon in the presence of finely divided copper. 11 About % of the total copper needs is added to the high temperature zone of the arc furnace as large chunks.

The reduction furnace is about 6 ft. outside diameter and about 10 ft. high. The vertical portion is lined with carbon brick and has a 12 inch layer of carbon brick at the bottom. The inside diameter of the reduction chamber is about 45 inches. A tap hole is provided at a level flush with the bottom floor. The top, completely enclosed except for an exhaust port, is fabricated of stainless steel. Water cooling adaptors on the top help to

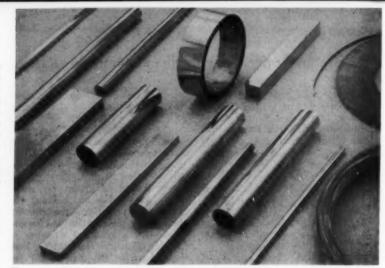


Figure 6. Typical wrought shapes of beryllium copper.

dissipate the heat. Three 7 inch diameter electrodes, oriented in triangular form, extend below the surface of the furnace charge striking an arc with the pool of molten metal at about 72 volts, phase to phase. The furnace consumes about 750 kilowatts of power. The alloy is tapped approximately once an hour, and the charge is maintained at a constant high level.

The hot metal is tapped into a graphite lined ladle. Base metal oxides are added and stirred vigorously in order to react with and agglomerate the dross at the surface where it can be easily removed. The metal is then poured into 20 pound ingots in cast iron molds, weighed, and sent to a Detroit-type rocking surface for refining. Refined metal is cast into 5 pound ingots for shipping or further alloying and conversion into wrought products and castings.

The temperature in the arc furnace ranges from 2200°C. to 2400°C. At this temperature the carbon reduces the beryllium oxide to beryllium metal.

Equation 7. BeO + C → Be + CO Unalloyed metallic beryllium cannot be produced in this manner. Without a base metal present for immediate alloy formation, the beryllium formed would react with excess carbon to form beryllium carbide.

EQUATION 8. 2Be + C -> Be C

The maximum percentage of beryllium in copper that can be produced efficiently in this process is about 5½ percent. The exact mechanism for this conversion has been disputed for many vears. Kroll\* has suggested that beryllium oxide is first reduced to beryllium carbide, which in its turn reacts with copper to form copper beryllide.

EQUATION 9. 3Be<sub>2</sub>C + 2Cu → 2Be<sub>3</sub>Cu + 3C

The commercial alloys of beryllium copper known as Berylco 25, Berylco 165, Berylco 10 and Berylco 50,

which contain from ½ to 2 percent beryllium are made by dilution with the correct amount of copper and other alloying constituents. These alloys are cast in sand, investments and permanent molds, or pressure castings according to customer specifications or use requirements. Some wrought shapes of beryllium copper are shown in Figure 6.

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# UREA

Urea synthesis is not a simple process from either the design or the operating standpoint. A great number of variables affect both the production rate of urea and the amount of corrosion which occurs. Sound engineering and operating practices, however, have made possible its development into a profitable commercial process. Nevertheless, many of the operating techniques, especially with regard to decreasing the corrosion, are still an art rather than a science and the further improvement of this process presents a continuing challenge to chemical engineers.

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UREA, A WHITE, CRYSTALLINE, relatively nontoxic organic chemical compound, NH2CONH2, with a melting point of 132.7°C., was first isolated in 1724 by crystallization from urine. It is of historical interest since its preparation by Wohler in 1828 by the isomerization of ammonium cyanate is generally believed to be the first synthesis of an organic compound from an inorganic source. Up to that time, little more than a century ago, it was widely held that the compounds occurring in plants and animals had some kind "vital force" which distinguished them from inorganic compounds. Wohler's discovery helped to break down the sharp boundary between organic and inorganic chemistry. Since that time many methods have been developed for the synthesis of urea. However, the one of major importance is the Bassarow dehydration of ammonium carbamate, since it is the one on which all commercial processes are now based. The reaction is illustrated by the following equation:

$$\begin{array}{c} 2 \text{ }_{\text{NH}_3} \\ \text{(Ammonia)} \end{array} + \begin{array}{c} \text{Co}_2 \\ \text{(Carbon} \\ \text{Dioxide)} \end{array} \\ \text{NH}_4\text{COONH}_2 \\ \text{(Ammonium} \\ \text{Carbamate)} \\ \text{NH}_2\text{CONH}_2 + \begin{array}{c} \text{H}_2\text{O} \\ \text{(Urea)} \end{array}$$

Although the reaction dates back to 1870, it did not attain commercial importance until 1920, when the I. G. Farbenindustrie made it into a commercial process. The advantage of this reaction is the use of relatively cheap raw materials. Carbon dioxide is obtained as a by-product of the hydro-

gen produced for ammonia synthesis. A large portion of this carbon dioxide is generally purged to the atmosphere. Therefore, its recovery and use in a salable product is of economic importance. At this time, there are three major uses for urea in the United States: as fertilizer, as cattle feed, and as raw material in plastics manufacture.

#### The process

Before we discuss the various steps of manufacture of urea and the factors affecting each step, it would be beneficial to consider a simplified flow sheet. See Figure 1.

Ammonia and carbon dioxide are compressed and fed continuously into an autoclave which is maintained at a sufficiently high temperature and pressure to form a melt of ammonia, carbon dioxide, ammonium carbamate, urea, and water. A continuous stream of the melt flows from the autoclave, through a pressure let-down valve, to the carbamate stripper where the melt is separated into a liquid phase of urea and water (and perhaps varying amounts of ammonium carbamate and ammonia) and a gaseous phase of ammonia, carbon dioxide, and small quantities of water. This gas is re-cycled to the process or used in the production of by-product salts. The liquid product of the carbamate stripper can be used in the preparation of urea-ammonia solutions or it can be processed further to produce a solid urea.

We can now study the effect of several process variables and the problems associated with each of the four steps of urea manufacture.

#### Autoclave reaction

In the autoclave, the urea melt is maintained at a specific temperature, somewhere between 135° and 200°C., and at autogenous or higher pressures (usually 1,500 to 5,000 p.s.i.) for a suitable length of time. The main variables (and these are all interrelated) which affect this reaction are temperature, pressure, feed composition, and reaction time. They all affect the yield of urea, the heat balance, and the corrosion of the materials of construction.

The urea synthesis reaction is highly exothermic, therefore, proper control of the reaction temperature is very important from the process and the corrosion standpoint. The autoclaves require external cooling jackets and/or internal cooling coils. Certain aspects of some of the existing commercial processes aid in the temperature control. These will be discussed later.

#### Temperature effects

Under the usual conditions for urea synthesis, the reaction of ammonia with carbon dioxide to form ammonium carbamate is essentially spontaneous. However, variations in temperature and pressure greatly affect the rate of dehydration of ammonium carbamate to urea. Figure 2 illustrates the effect of temperature on the overall reaction rate.

It can be seen that the conversion of carbon dioxide to urea gradually increased as the reaction temperature increased, until it reached approximately 45 percent at about 180° C. The conversion then suddenly decreased with increasing temperature.

This decrease in conversion with increase of temperature above a certain point can be explained by Figure 3. This chart is a plot of dissociation pressure of ammonium carbamate versus temperature. It indicates that the dissociation pressure of ammonium carbamate reaches 185 atmospheres or 2,700 p.s.i. at about 190° C. Thus, if the dissociation pressure of ammonium carbamate at the reaction temperature is near, or higher than the operating pressure, poor conversions will result. Increasing the temperature further, lowers the conversion. This dissociation curve of pure ammonium carbamate does not give the true dissociation pressure of ammonium carbamate in the urea melt (due to the effect of the other compounds which are present, particularly the excess ammonia) but it is a valuable guide for determining an approximate upper temperature limit at which the autoclave should be operated for any particular operating pressure.

Pressure has a marked effect on the reaction rate and thus the conversion of carbon dioxide to urea during urea synthesis. See Figure 4.

It can be seen that at a reaction pressure of 2,200 p.s.i., the conversion of carbon dioxide to urea was only about 35 percent. With increase in pressure the conversion increased rapidly, up to about 57 percent at 4,000 p.s.i., and then tended to level off. However, no maximum point of conversion was obtained.

The effects of feed rate and excess ammonia on the conversion of carbon dioxide to urea and the urea production rate were studied in the pilot unit. Data were obtained at 175° C and 2,700 p.s.i. and is presented in Figure 5. These curves show that increasing the total feed rate decreases the conversion of carbon dioxide to urea, but increases the urea yield. They also show that excess ammonia increases the conversion of carbon

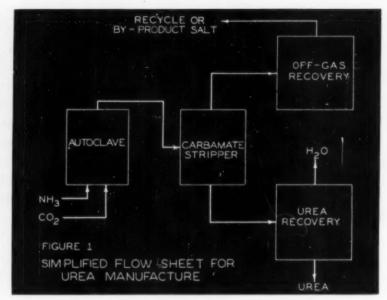


Fig. 1. Simplified flow sheet for urea manufacture.

dioxide to urea, but that for any specific total feed rate, excess ammonia decreases the urea yield. Thus, from an operating and capital cost standpoint, an optimum feed rate and ammonia to carbon dioxide ratio must be determined.

It has been apparent that the rate is increased by:

- 1. Increased pressure.
- Increased temperature (so long as the operating pressure is substantially above the dissociation pressure of ammonium carbamate).
- 3. The use of no excess ammonia.

The question then may be asked, "Why not operate at the maximum pressure and temperature possible, and with no excess ammonia?" There are several reasons why this should not be done. Increased pressure increases the capital and operating costs of compression and reaction equip-

ment. Increased temperature accelerates the decomposition of urea to biuret—a compound which is detrimental to germinating seeds and to animal life. But most important, all of the above conditions accelerate the corrosion rate in the reaction system. They do this to such a great extent, and so severely under certain conditions, that the reaction must be conducted under conditions which result in a tolerable corrosion rate rather than under those which result in maximum production of urea.

A considerable amount of data has been reported concerning the corrosion rates of various materials under urea synthesis conditions. Much of this data is very conflicting, probably due to the great number of factors affecting the corrosion rates, some of which are known and some of which are not. Since it was believed that some commercial processes were operating suc-

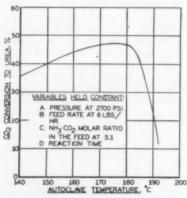


Fig. 2. Effect of temperature

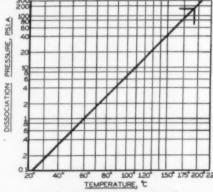


Fig. 3. Dissoc. press. of carbamate

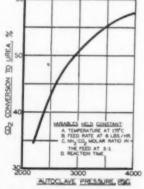


Fig. 4. Effect of pressure

cessfully using a reactor fabricated from a stainless steel, most of the pilot plant investigations were concerned with the testing of various stainless materials. Some representative corrosion data are listed in Table I.

	TABLE I	
	Highest	Lowest
	Corrosion	Corrosion
	Rate	Rate
Material	Obtained,	Obtained,
Tested	Inches/Year	Inches/Year
410 S.S.	Total Loss	
304 S.S.	5.4	0.0002
321 S.S.	0.9	0.0003
Nickel	3.0	
Pfaudler Gla	ass 0.6	
Hastelloy C	0.18	0.10
Carpenter 2	0 0.3	0.08
Worthite	0.26	0.004
Teflon	<ul> <li>Weight Gain a</li> </ul>	nd Blistered-
Tantalum	0.009	0.001
Alloy Z	0.008	0.0003

The highest and the lowest corrosion rates obtained are given to show the tremendous effect of operating conditions on the rate of corrosion. In general, it can be said that the corrosive conditions of the urea synthesis reaction are very severe. Only a few materials showed any semblance of being resistant. The fact that glass had a corrosion rate of 0.6 inches per year and that Teflon blistered very badly is indicative of the corrosive nature of this reaction. Tantalum showed good corrosion resistance for all tests to which it was exposed but its high cost rules out its use-except perhaps, as a very thin liner. The last material listed exhibited corrosion rates which would make it quite acceptable as a material of construction for urea synthesis equipment.

#### Carbamate stripping

A constant stream of the urea synthesis melt flows from the reactor, through a pressure let-down valve, to the carbamate stripper. This stream is

° Called Alloy Z by the author.

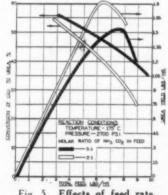
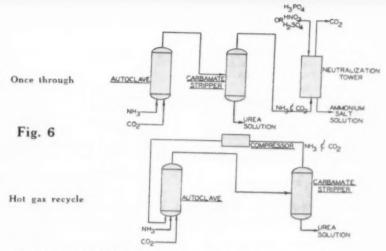


Fig. 5. Effects of feed rate, excess NH,



cooled due to the flashing which occurs. Therefore, the temperature of the material entering the carbamate stripper is a function of the operating pressure of that vessel. Additional heat must be added to vaporize soluble ammonia and decompose ammonium carbamate in the carbamate stripper, if it is desired to decrease the quantity of ammonium carbamate and soluble ammonia in the liquid product.

If temperatures much above 110° C are used in the carbamate stripper, decomposition of some of the urea to undesirable biuret will occur. The higher the temperature, the faster this decomposition will be.

Very corrosive conditions exist in the carbamate stripper. However, it has been found that several metals and alloys which are normally used in chemical plants have satisfactory corrosion resistance.

#### Urea recovery

The weight ratio of urea to water in the liquid product of the carbamate stripper is about 3 to 1. Therefore, if all the ammonium carbamate were dissociated in the stripper, its liquid product would be a urea-water solution having a urea concentration of approximately 75 weight percent. To form a solid material for sale, this urea-water solution can be spray dried, evaporated and crystallized, or evaporated and prilled. During this processing, the time which the material is held at temperatures above 110° C must be kept at a minimum to lessen the decomposition of urea to biuret.

#### Off-gas recovery

The conversion curves discussed above have indicated that the conversion of carbon dioxide to urea during urea synthesis is only about 50 percent per pass. Since excess ammonia is normally used, its conversion is usually even less than this. Conse-

quently, recovery of these gases, especially the ammonia, is mandatory from an economic standpoint. The major differences between the existing commercial processes are in the methods by which this recovery is effected. Some of the major urea processes used today (and some which have been used in the past) are briefly described below with the advantages and disadvantages of each. Simplified flow sheets of these processes are shown on Figures 6, 7, and 8.

The autoclave step is fundamentally the same for all of these processes, and for all of them, the urea product will be represented as a urea solution. This solution could be processed further to produce the desired final product. However, this processing is identical for all the processes considered. Primarily, then, only the off-gas processing methods and their effects on the rest of the process will be discussed.

Once Through process. The unconverted ammonia and carbon dioxide gases which leave the carbamate stripper are not recycled to the autoclave. Therefore, for this process to be economically attractive, these off-gases (at least the more expensive ammonia) must be reclaimed in some manner. This is usually done by neutralization with sulfuric, nitric, or phosphoric acid to form a by-product ammonium salt for sale.

The biggest advantage of this process is:

The low capital investment required. The major disadvantages are:

High corrosion rates.

The need for integration with sulfuric, nitric, or phosphoric acid facilities.

"Hot Recycle" process. The unconverted ammonia and carbon dioxide are compressed together to the autoclave reaction pressure and recycled to the autoclave. It has the advantage of: good overall conversion of both ammonia and carbon dioxide.

Its disadvantages are:

During the recompression of the ammonia and carbon dioxide, very close control of the compressed gas temperature must be maintained to prevent solid ammonium carbamate formation with resultant damage to the compressors.

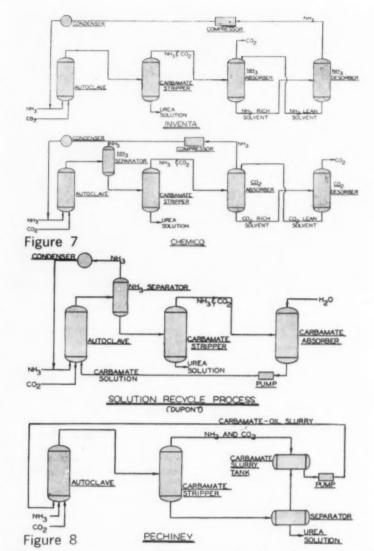
Since the compressed gases are hot when fed back into the autoclave, the temperature control of the highly exothermic reaction is made more difficult.

"Inventa" process. Unconverted ammonia is recovered and the carbon dioxide is vented. The unconverted gases exit from the carbamate stripper and are fed into an ammonia absorber where the ammonia is absorbed in an aqueous urea nitrate solution and the insoluble carbon dioxide is vented from the top of the tower. The "ammonia-rich" solvent then passes to an ammonia desorber. The desorbed ammonia gas is compressed to reaction pressure and then condensed before being fed into the autoclave. This process has a good overall ammonia conversion.

The liquid ammonia recycle aids in the proper control of the autoclave temperature.

"Chemico" process. It is quite similar to the "Inventa" process in that only the unconverted ammonia is recovered. This is accomplished by feeding the unconverted ammonia and carbon dioxide gases from the carbamate stripper into a carbon dioxide, rather than an ammonia, absorber. The unabsorbed ammonia passes through and is compressed, condensed, and then recycled to the autoclave. The "carbon dioxide-rich" monoethanolamine solution is then regenerated in the desorber by driving off and venting the carbon dioxide. The "Chemico" process has the same advantages as the "Inventa" process.

"Solution Recycle" process. The unconverted ammonia and carbon dioxide from the carbamate stripper are absorbed in water to form an ammonium carbamate solution which is pumped back to the autoclave. Since this excess water would tend to decrease the urea yield, a large quantity of excess ammonia is used in the reaction. Much of this ammonia is separated from the melt in an ammonia separator located between the autoclave and the carbamate stripper. This ammonia is condensed and recycled to the autoclave. The process has the following advantages:



Good overall conversion of both ammonia and carbon dioxide.

The excess water used in the carbamate solution aids in the temperature control of the autoclave. However, it has the following dis-

advantages:

The excess water makes high temperatures and pressures necessary in the autoclave in order to obtain good conversions per pass.

"Pechiney" process. This differs from the others in that the reaction and recycling are carried out in a mineral oil medium. The mineral oil-urea melt mixture passes from the autoclave to the carbamate stripper where unconverted ammonia and carbon dioxide are driven off. The liquid phase of the stripper is then decanted in the oil separator. Urea solution is withdrawn from the bottom while the oil layer is transferred to the slurry vessel where the unconverted gases react to form crystals of ammonium carbamate. This carbamate-oil slurry is recycled to the autoclave. The "Pechiney" process has good overall conversion of both ammonia and carbon dioxide.

The presence of the oil aids in autoclave temperature control and also lessens the corrosion problem.

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City, Missouri.

# Engineering problems in Large-scale Electrophoresis

Electrophoretic processes to date have been on a laboratory scale. Here are the problems to be considered for design of plant-scale operations.

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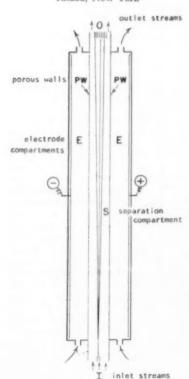


Fig. 1. The principle of operation.

E LECTROPHORESIS IS THE MIGRATION of charged particles in an electrical field. Individual particles move either to the positive or negative electrode and thus reveal the sign of the charge which they carry. The rate of movement as well as the direction may differ in any mixture containing several species, and this has become the basis for laboratory fractionation of colloids or of charged macromolecules such as proteins.

The velocity of a particle in a potential gradient of 1 volt/cm is termed its electrophoretic mobility. The mobilities of ions in water at room temperature range from 2 to 35 microns per second and strangely enough, colloidal particles have comparable mobilities. The speed of proteins is generally lower; it is measured in tenths of a micron per second. All such statements must be qualified because pH and concentration of electrolyte in the suspending medium influence the degree of hydration and the charge on a particle, thereby affecting its mobility. Ampholytes like proteins and amino acids do not move at all when at their isoelectric pH. In addition, the viscosity of the medium and the size and shape of the particle play their usual role in the hydrodynamics involved. Under favorable circumstances, a complex mixture can be split into a spectrum-like pattern of individual components. The extent of such a separation depends upon the strength of the applied field and residence time of the mixture within the field.

Because electrophoresis has turned out to be such an elegant method for analytical and preparative work in the laboratory, there would no doubt be industrial applications as well as scientific interest if one could fractionate liters per hour instead of milliliters per hour. No matter what the outcome the challenge of developing a new unit operation is an exciting business for chemical engineers.

Review of laboratory methods

A reasonable first assumption is that some slight modifications of existing apparatus might allow purifications on a larger scale. This proved to be untrue but due consideration was given to the most desirable features of present techniques. These may be classified as follows:

1. The Moving Boundary. This method, refined by Tiselius, still ranks as a classic in electrophoresis and is fully described in an excellent review by Alberty (1). Separation takes place in a U-tube. The dilute buffer which serves as a suspending medium is maintained at a temperature near its maximum density (i.e. near 4°C) while the mixture itself is stabilized at the lower curved portion of the tube by its higher density. The pH is such that all components move in the same direction and the individual boundaries are observed by optical means.

2. Zone Electrophoresis. Here the medium is stabilized against convection by finely divided solids rather than by gravity, and complete separation of the individual components into distinct zones is possible. Materials used as anti-convection supports include sheets of filter paper (17, 12) or columns of cellulose (10) starch (11), glass powder (13), asbestos fiber (6), and gels or very viscous fluids (22).

3. Electroconvection. Electroconvection accomplishes separations by taking advantage of the combined effects of horizontal migration due to electrophoresis and vertical natural convection due to the higher density

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of a concentrated suspension of particles (5). Separation takes place in a channel bounded by semipermeable membranes and narrow enough to assure a short path for the migration. Mobile components travel toward one or another of the retaining walls and are swept downward for removal by natural convection. Only a single component, immobilized at its isoelectric point, can be separated at a time in high purity.

4. ISOELECTRIC SPECTRA. This technique recently proposed by Kolin (16) takes advantage of differences in isoelectric point as well as differences in mobility. The mixture to be separated is layered between two liquid media, one acidic and one basic. The range of pH is chosen to include within its limits the isoelectric points of all the components being fractionated. The systems are stabilized against gravity mixing by adding appropriate amounts of sucrose to the liquids which make up adjacent layers. After diffusion establishes a pH gradient in the middle layer and a potential field is applied, components migrate to form sharp zones in locations that correspond to their isoelectric pH. The Kolin technique has also been applied to paper electrophoresis (15).

All of the above methods have first been used batchwise but in recent years continuous operation has been favored for preparative work. Durrum (9) developed a continuous apparatus in which the mixture flows in a narrow streak down a vertical sheet of filter paper at a rate of about 0.1 ml per hour. A buffer solution is also applied to the "hanging curtain" and under the action of a transverse electrical field the various fractions fan out into separate purified fractions. These are collected at the bottom edge of the paper which is serrated to form numerous drip-points. A similar version of continuous zone electrophoresis was developed by Brattsten (4) who worked with long rectangular columns packed with powdered glass. The capacities are of the order of milliliters fractionated per hour.

Bier (3) has proposed a new technique for preparative electrophoresis which is related in some ways to electroconvection. The mixture is forced to flow downward inside the fractionation channel and migrating components continue to flow downward by gravity next to the semipermeable wall. A particular component held at its isoelectric point remains in the original stream which is diverted by baffles and withdrawn separately. Only one component at a time can be separated in high purity but fractiona-

tion rates as high as 4 ml/min have been reported.

A certain amount of heating is unavoidable because of passage of electrical current, and in large apparatus its complete dissipation becomes exceedingly difficult. Therefore it seemed inadvisable to depend on natural convection by gravity differ-ences for any part of the separation procedure. On the other hand, anticonvection media did not seem to offer a solution. The low throughput characteristic of zone electrophoresis might be increased for example by applying pressure but there are other difficulties. Because the surfaces of most finely divided solids are themselves charged, the packing material tends to cut down the mobility of the particles as compared to their mobility in free liquid. Moreover, there is electroosmotic flow of the suspending fluid through the interstices of the porous packing and such bulk flow distorts the separations. Still another

complication is that particular components may be adsorbed onto the solid surfaces. If the particle size of the packing material is increased, then the well-known diffusion effect of packed beds comes into play to cause dispersion of the filaments (2).

In the apparatus which was finally developed, the mixture to be fractionated is introduced as a broad thin ribbon into a buffer solution passing upwards in laminar flow between two vertical electrodes. When a potential is applied, the single ribbon or band splits up into individual bands, one for each separable component (Figure 1), and under favorable conditions these are sufficiently well separated to be withdrawn in different streams from the top of the column where a series of knife-edged flow splitters is located. Figure 2 shows some of details of construction. The overall height is about 5 ft. The vertical column in which separation occurs is rectangu-

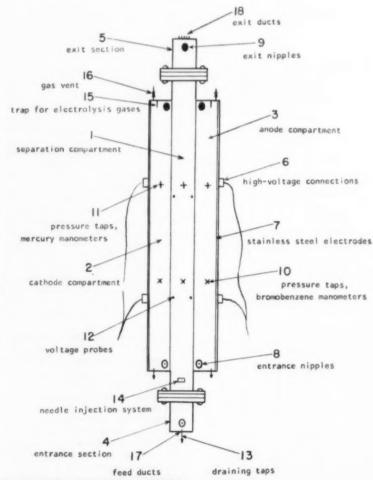


Fig. 2. Schematic diagram of Plexiglas apparatus.

lar in cross-section and measures about 3 in. by 2 in. Electrodes are located in special compartments separated from the main column by porous walls. A more complete description of the apparatus is available (7) and its performance in separating dye mixtures has already been reported (8), but some of the engineering problems involved in its design are described in the following paragraphs.

#### Materials of construction

The apparatus itself and components in the immediate vicinity must be good insulators because several hundred volts of D.C. potential are applied to the electrodes. The use of Plexiglas allowed observation of flow patterns inside the column and greatly simplified the construction of the apparatus.

The porous walls prevented bulk transfer of fluid between compartments; such transfer would upset the flow pattern in the fractionation zone and might also cause pH changes from the products of electrolysis. Because semipermeability is not required rigid partitions with pore diameters in the order of microns can be used instead of cellophane. Walls of sintered stainless steel were tried but the sides facing the anode became cathodic and the opposite sides became anodic. Within minutes there was gas evolution from both sides of each porcus wall and as a result the flow in the central column was distorted. Electrical conductivity therefore eliminated the use of metals or carbon. Porous glass or porous ceramics proved to be too fragile, and consideration of plastic materials finally resulted in the choice of Flexolith.1 This is an acrylic resin and its compatibility with Plexiglas was most helpful during fabrication. Though its use is limited to temperatures below 70°C, Flexolith was superior to other porous plastics in both costs and mechanical strength.

Among the factors which must be weighed in choosing a partition are: electroosmotic effects, specific electrical resistance or voltage drop through the partition, and bulk flow between compartments by pressure differences. Electroosmotic flow comes from surface charges on the material itself or acquired through adsorbed ions. Future development of new porous diaphragms may eliminate electroosmosis but it was not a severe problem because opposing pressure differences were maintained in the

apparatus. Voltage drop across a porous wall is less when the porosity is high while resistance to bulk flow is favored by low porosity and small pore size. Although one must compromise between these conflicting demands, the number of alternatives is small and choice is limited.

#### Electrode reactions

Early in the investigation it was felt that excessive gassing in the electrode compartments could not be tolerated because its effects would be transmitted through the porous walls and upset flow conditions in the fractionation zone. Therefore some thought was given to reversible electrode reactions which do not involve gases as electrolysis products. As it turned out, gas evolution constituted a problem only when conditions in the electrode compartments were static; i.e., when the compartments were filled with liquid and blanked off during operation. After flow was established in the entire apparatus. electrolysis gases were collected in special traps and vented, and their effect on the internal pressure was practically negligible.

Frequent replacement of electrodes is a nuisance and even more important, their corrosion can introduce contaminants into the fluid streams and make them unsuitable for reuse. Stainless steel and carbon appear to be satisfactory as cathodes, but they are unsuitable as anode materials because the first corrodes and the second disintegrates, especially at higher current densities. Noble metals, though high in initial cost, may become economical upon prolonged use, particularly with the advent of better and cheaper plating and coating techniques on common base metals. It appears that Ionics, Inc.,1 in working on their desalination units, have found Hastellov C and Tirrellov B2 most satisfactory as anode materials under conditions which are considerably more severe than those encountered in electrophoresis.

#### Fluid flow

A most crucial problem in this type of continuous apparatus is the establishment of an initially flat velocity profile and maintenance of steady laminar flow over the entire height. Any waviness in the streamlines will make separation impossible.

The laminar-turbulent transition has been carefully studied by Rothfus and co-workers who report (21) that the first observable departure from

Fig. 3. End-section open to show flow splitter.

laminar flow occurs at the point of maximum velocity in the form of irregular waves. The critical Reynolds number is about 1225 for pipes and 700 for annular ducts. In dye fractionation tests with the present apparatus, maximum Reynolds numbers were 200 for the column and 130 for the annular space around the flow splitter at the top; these are far below any critical value, and perfectly straight bands of dye were obtained.

However, careful attention had to be given the inlet and outlet. Since the knife-edged ducts were located in the center of the column, it was necessary to introduce and withdraw background electrolyte through side walls of the end-sections (see Figure 2). To damp out turbulence in the entering liquid and distribute it evenly in the annular spaces, a series of equally spaced screens was placed between the main column and the end-sections. Fairly good results were obtained in this manner only over a limited range of flow rates. Although there was no severe waving some distortion of the streamlines was caused by the flow splitter, which occupied about one-third of the total area at the top of the column. Two recent reviews on the techniques for flow distribution (23, 24) may be helpful in future attempts to modify and improve the present design.

Distribution of the feed mixture required that a duct measuring 0.10 in. by 0.25 in. be expanded to a larger duct 0.10 in. by 2.0 in. The feed mixture tended to pass as a beam through the center of the expanding duct and a variety of packing materials such as glass beads failed to distribute the flow evenly. Finally a special spiral packing was prepared by twisting narrow strips of stainless steel to

<sup>&</sup>lt;sup>2</sup> Marketed by Filtros, Inc., East Rochester, New York.

<sup>&</sup>lt;sup>1</sup> Cambridge, Massachusetts.

<sup>&</sup>lt;sup>3</sup> Developed by C. E. Tirell of Ionics, Inc.

form 45° spirals (7 to 8 turns per inch). Segments of this material, varying in length from % in. to 2 in.; were sealed into the sloping walls of the expanding duct about % in. apart. This worked very well even at the low flow rates and was used in all ducts designed to introduce the feed and withdraw the separated fractions.

#### Resolving power

Since retention time in the column is only 3 or 4 minutes, molecular diffusion is not likely to be significant for substances of high molecular weight. Therefore, the bands of dye can be expected to remain fairly sharp as they fan out and proceed upward. Under conditions of plug flow resolution may be expressed as:

$$\Delta s = \frac{(\Delta \mu) E H}{u}$$
 (1)

where

 $\Delta s = distance$  between centers of any two bands (cm)

 $\Delta_{\mu}$  = difference in mobility between the two components (cm<sup>2</sup>/ volt-sec)

E = potential gradient (volt/cm) H = height of fractionation zone

(cm)

u = liquid velocity (cm/sec) In practice, u must be replaced by the maximum volocity (um). The actual retention time may be as little as half the average value, depending on the extent to which a parobolic velocity profile becomes established.

#### Heating effects

When a voltage is applied to the apparatus flow problems are more severe because the heat that is generated gives rise to natural convection currents. For a uniform flow profile, the increase in temperature of the

$$\Delta t = \frac{0.24 \text{ E}^2 \text{ k H}}{\rho \text{ c u}} \tag{2}$$

where, in addition to nomenclature defined earlier.

 $\Delta t = \text{temperature rise (°C)}$ 

0.24 = a conversion factor (cal/joule)

k = electrical conductivity

 $(ohm^{-1}cm^{-1})$ 

ρ = liquid density (gm/cm<sup>3</sup>) c = specific heat (cal/gm.°C)

Close temperature control or external cooling, as used in laboratory devices, was difficult to incorporate into large-scale equipment. Moreover, it was felt that a small temperature rise would be all right since expansion of the liquid on heating merely serves to aid the upward motion. Equation 2 does not tell the whole story, however. Heat is generated at a fairly constant rate per unit volume. but not all portions of the fluid have the same retention time. Because of the velocity profile, local values of Δ t can range from one-half to several times the average value calculated from Equation 2, and temperature gradients develop between adjacent layers of fluid. Furthermore, heat is generated in the porous partitions at a rate considerably higher than in the free liquid and this is partly dissipated in the fractionation zone. All these thermal effects gave rise to a pattern of "waving" observed at high voltages close to the top of the column. The sinuous motion was very similar to streamlines of thermal convection forming next to a hot vertical wall

Methods for stabilizing the convection will be discussed in the next section, but it is obvious that to minimize electrical heating one should lower the conductivity by using a small amount of electrolyte. The presence of some electrolyte is necessary to maintain dye or protein mixtures in solution, to preserve the pH and ionic strength of the medium, and to minimize "boundary anomalies" due to differences in conductivity between the feed mixture

and background solution.

Because the control of waving is so important to the success of this apparatus in more difficult separations. further studies on the heating effects are planned. Interest in natural convection phenomena, with or without internal heat sources has been growing steadily in recent years in connection with the design of circulating-feed nuclear reactors (20), and the cooling of turbine blades by internal convection currents (19). Unfortunately, this and related work in the literature offer hardly anything of immediate value to the problem at hand. Here heat is generated internally with relatively little transfer at the walls, and because of the short retention time no steady state can be assumed. It should be interesting to establish the criteria for the onset of thermal interference with steady laminar motion and to establish how these criteria are affected by the Reynolds number.

#### Convective mixing

To overcome convective mixing many of the early devices used anticonvection media or they were operated at temperatures close to the density maximum of water. The approach here has been to use forced laminar flow, and, as an added provision, liquids of high viscosity. The significance of viscosity and other important variables can best be understood in terms of the Grashof number:

$$N_{Gr} = \frac{H^3 g \rho^2 \beta \Delta t_l}{\eta^2}$$
 (3)

where

H = characteristic linear dimension (height of column)

g = acceleration of gravity

 $\rho = \text{density of fluid}$  $\beta$  = coefficient of thermal expan-

Δt<sub>i</sub> = characteristic temperature dif-

η = viscosity of fluid

One has to be a little circumspect in applying this. For example, if the height is cut in half, the potential gradient must be doubled in order to get the same resolution. Even though the nature of the characteristic temperature difference (\$\Delta\$ t<sub>1</sub>) is not known, it may be expected to double under the new conditions in general accord with Equation 2. The overall result is that any variation in height will affect convection as H2 rather than H<sup>s</sup>. Since height of the fractionation zone cannot be reduced indefinitely, experimental investigation may show an optimum height.

Similarly any advantage from high viscosity is partly offset by a proportional reduction in electrophoretic mobility. There is a way to overcome this particular restriction, however. Structural viscosity as exhibited by dissolved polymers is quite different from the viscosity contributed by solutes like glycerol or sucrose. Although the polymer solution is viscous with regard to bulk flow, water held within the fibrillar structure of longchain molecules acts like free water and therefore the mobility is almost unaffected by the presence of polymer. The thickening agents chosen for electrophoresis should be water-soluble polymers such as dextran, polyvinyl alcohol, or methyl cellulose which are essentially uncharged. Carboxymethyl cellulose, for example, is not so satisfactory because it tends to migrate in the electrical field. In the work with dves no absorption or complexing was observed when using Methocel,1 but it remains to be seen if proteins will require the use of another thickener.

Thus far solutions of only 10 cp have been tried but the Grashof number suggests that a 100-fold increase in viscosity would make the system 10,000 times more stable against convection. On the other hand, if the correct modulus for predicting disturbance to flow is not the Grashof number itself but the ratio N<sub>Gr</sub>/N<sub>Re</sub> (14), then viscosity will enter as the first

The Dow Chemical Company, Midland, Michigan.

power instead of as the square.

In addition to viscosity, one must also recognize the role played by the coefficient of thermal expansion  $(\beta)$ . Even though external cooling is not provided in the apparatus, it is advantageous to work close to the density maximum of water, i.e., from 0 to 8°C, where the value of \$\beta\$ is relatively small.

#### Capacity

Fractionation capacity is determined by the dimensions of the feed stream. i.e., the thickness of the band and its width perpendicular to the electrical gradient. Provided the feed stream is admitted to the central portion of the column, it should maintain itself fairly well. If too wide, however, it may extend into a region near the walls where the local velocity is appreciably different from that in the core of the column, and distortion will result from the varying retention times along the width of the ribbon. Thickness of the band is also subject to limitations because for thick bands more lateral movement is required to completely separate any two components. In other words the resolving power of a particular apparatus is diminished. Also, if the band of mixture is rather thin it is dragged along by viscous forces in the flowing background medium, but if too thick it acts like a slug of a different liquid and may tend to rise or settle depending on the densities. Such effects can be minimized by the use of high viscosity or by proper adjustments of the densities of feed and background solutions.

The dimensions of the feed duct were set at 40 mm x 2 mm but it was desirable to introduce the feed under hypokinetic conditions so that the ribbon was thinned out on emerging from the duct. Capacities up to 9 ml/min were obtainable with a linear velocity of 0.5 cm/sec for the background solution.

#### Design limits

The following treatment is intended for order-of-magnitude estimates only. To simplify matters, therefore, plug flow is assumed and the following set of conditions is chosen as a typical example of what might be encountered in a protein separation.

H = 100 cm

 $\Delta \mu = 10^{-5} \text{ cm}^2/\text{volt-sec}$ 

k = 10-4 ohm-1-cm-1

c = 1 cal/gm.°C

 $\rho = 1 \text{ gm/cm}^3$ 

A series of calculations based on Equation 1 is summarized graphically in Figure 4. The solid lines are plots of resolution against potential gradient, using liquid velocity as parameter. Elimination of the term H/u between Equations 1 and 2 gives

$$\Delta s = \frac{(\Delta \mu) (\Delta t) \rho c}{0.24 E k} = \frac{\Delta t}{2.4 E}$$

Plots of As vs. E corresponding to temperature rises of 0.2, 2.0, and 20°C, respectively, are presented in the same figure.

Consider the following set of hypothetical conditions:

1. Thermolability of product dic-

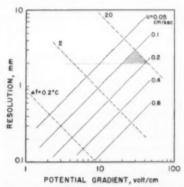
tates  $\Delta t = 20$ °C as an upper limit. 2. Design of the knife-edged flow splitter requires  $\Delta s = 2$  mm as a min-

3. Maintenance of steady flow conditions demands a minimum flow rate of u = 0.1 cm/sec

The triangular area bordered by corresponding lines in Figure 4 represents the only region where operation is possible. The limits chosen here are rather arbitrary, but the cross-plot serves to illustrate the interrelation among variables. Thermal effects will undoubtedly become serious long before the 20° limit set here, but actual restrictions would have to be determined by experiment.

#### Conclusions

The good separations that have been achieved with simple dyes could be readily applied to the separation of other highly mobile substances. It



A cross-plot of resolution and Fig. 4. thermal effects.

should be possible to recombine and recirculate streams leaving the electrode compartments and background medium leaving the fractionation column. The Bier apparatus or similar devices based on the principle of electrodecantation (25) could be used to concentrate the product streams and separate the product from the thickening agent if necessary. Since operating conditions for separation of dyes were close to the upper limit of the apparatus in its present form,

considerable improvement will be necessary to fractionate proteins that are only about one-tenth as mobile. Additional work on the distribution of fluids entering and leaving the equipment is desirable, and further study must be made of the conditions which lead to a steady and reproducible flow pattern. A number of most important variables such as flow rate, viscosity, buffer concentration, and height of the fractionation unit have not yet been studied extensively. Future refinements may eventually lead to economical separation of enzymes and serums on a large scale.

#### Acknowledgment

This investigation was supported in part by research grant H-2216 from the National Heart Institutes of the National Institutes of Health, Public Health Serv-

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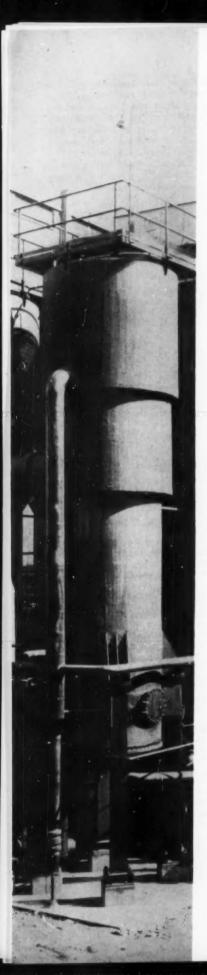
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# Planning Economical Kraft mill evaporators

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K RAFT MILL EVAPORATORS are frequently specified in terms of present requirements with little thought of future expansion requirements. Small increases in evaporator capacity become very expensive. Additional capacity can be made available at minimum cost by advance planning in the original installation.

The factors important to a properly planned installation are explained together with various means of increasing capacity. It will be shown that the selection of the proper number of effects is influenced by variables other than capital cost and operating cost. Relative costs of expanding planned and unplanned installations are given.

The modern multiple effect kraft mill evaporator requires and receives careful prepurchasing planning—generally aimed at controlling the initial capital investment and operating costs. This planning is usually confined to the immediate requirements of the evaporator at the initial pulp mill capacity. It is proposed that early consideration of the potential future pulp mill evaporation requirements will result in a more profitable investment.

The pulp capacity of a new kraft mill is originally determined by many economic factors including the market demand, available capital and raw material resources. With few exceptions this original installed capacity is later increased as the market for the product grows. The ultimate capacity of the pulp mill can usually be established based on market research, present and potential raw material resources and expected profit of the venture. Once the initial and ultimate capacity are set the sequence

of expansion steps required to reach the ultimate should be considered. In some cases these expansion steps are made in large increments necessitating doubling or tripling equipment throughout the plant. Under these conditions little difficulty is encountered with localized equipment bottlenecks. However, frequently the capital expenditure is more favorable if small capacity increases can be made to keep close pace with a growing market. Providing these small increases requires careful planning to avoid local equipment bottlenecks which can only be solved by costly installation of larger than required equipment.

The basic equipment units of the pulp mill which influence or are influenced by the evaporator are the digesters, brown stock washers and recovery furnace. They are all potential bottlenecks to uniform expansion. Of particular importance is the effect upon evaporator feed concentration of increased pulp tonnage over the brown stock washers. The close relationship of the pulp washers and evaporator has been previously stressed (1). It is necessary to establish the future pulp washer performance with increased tonnages in order to predict the future requirements of the evaporators. For the present evaluation it will be assumed that the brown stock washing system will be expanded to provide feed liquor to the evaporator at a constant concentration. There are many other equipment items involved but they are generally available in capacity increments which do not present expansion problems.

#### Methods of expansion

Any planned evaporator expansion must consider the basic heat transfer equation—

The total heat transferred in a multiple effect evaporator is the sum of the heat transferred in the individual effects. This is the sum of the  $UA\Delta T$  across each effect. Little can be done to change the coefficient U for particular conditions of liquor concentration and temperature level. Therefore, capacity increase requires an increase in either the heating surface  $\Lambda$  or the temperature difference  $\Delta T$  impressed across this surface.

The heating surface may be increased by the following methods:

1. Lengthening the tubes in existing bodies. This has become a frequent solution to expansion problems. Most pulp mill evaporators were originally installed with about 24 ft. long tubes. These can be lengthened by re-

moving existing tubes and lowering the bottom tube sheet the required amount. A spool piece is installed in the heating element shell to make up the difference. Capacity can be increased in direct ratio to tube length increase if the increase in vapor flow does not result in excessive pressure drop losses in the vapor handling systems. Tubes as long as 36 ft. have been successfully used in black liquor evaporators. This method involves considerable loss of production time which may be reduced by including by-pass or cut-out piping in the original installation.

2. Adding external heaters. External heat exchangers can be added to accomplish the sensible heating of the liquor transferred from effect to effect of the usual backward feed evaporator. This added surface will increase capacity about 10%. The method is frequently used to overcome a small capacity deficiency.

3. Adding bodies in parallel with existing bodies. An example of this would be the addition of a duplicate body in parallel with the last effect of an evaporator. If this were carried out the length of an evaporator, the capacity would be doubled and two evaporator lines would be formed. When only one effect is involved the increase might be about 10%. One advantage of this method is the reduced vapor loading with two bodies in parallel. This scheme is not favored because of operating problems associated with unevenly distributed heating surface.

4. Installing more tubes in existing bodies. In a planned system, future capacity can be provided by initially installing only a portion of the total tube capacity of the heating elements. At the same time, the other evaporator components such as vapor heads, condenser and pumps are also sized for the increased load. The usual practice is to drill holes for the total tube capacity in the tube sheet and cap the excess until such time as the additional tubes are required. Any desired increase in capacity can be provided with this method.

The temperaure difference may be increased by the following methods:

1. Increasing steam side temperature. This is accomplished by raising the steam pressure to the first effect. 65 lb./sq. in. gauge steam is the maximum recommended steam pressure for kraft mill evaporators of the vertical long tube type because of organic charring of the liquor at higher temperatures. Initially designing the evaporator system for a lower steam pres-

sure such as 35 lb./sq, in. gauge steam instead of an available 65 lb./sq. in. gauge permits the steam temperature to be increased from 281°F, to 312°F, at a later date. In a typical evaporator system this would provide about a 25% increase in capacity. This is an excellent and widely used method of increasing capacity but the step should be a planned one assuring the existence of a higher-than-design steam pressure when it is needed.

2. Reducing the liquor side temperature. This is normally accomplished by increasing the vacuum at the condenser. A standard condenser design vacuum is 26 in. of mercury equivalent to a saturated vapor temperature of 125°F. The initial condenser design vacuum might be set at 22 in. of mercury or 150°F. saturated vapor pressure. Proper sizing of the condenser would permit future operation at 26 in. mercury and 125°F, vapor temperature providing a 20% increase in capacity.

3. Reduction of vapor pressure losses. The flow of evaporated vapors from effect to effect results in a pressure drop between effects. This pressure drop which is necessary to cause flow of the vapors also represents a loss of  $\Delta T$  impressed across the heating surface. Careful attention to the sizing and arrangement of the vapor chambers and vapor piping will minimize this loss in pressure drop. Prior knowledge of an evaporator's future evaporation rate permits proper sizing to keep this loss within tolerable limits. A secondary advantage is the lower chemical loss from entrainment with a properly sized vapor system.

Any evaporator capacity gain must make use of one or more of the above methods. The proper choice will depend on the increase needed and the cost of the various schemes.

#### A typical mill expansion

In order to illustrate the benefits of planned versus unplanned expansions, an example mill will be assumed. This mill will initially produce 250 tons per day of pulp. It has been established that ultimately the mill will produce 750 tons per day of pulp. The initial digester installation consists of four 4,500 cubic foot digesters. The evaporator system can use any steam pressure up to 50 lb./sq. in. gauge. There will be 3,000 pounds total solids in the evaporator feed per ton of pulp. The feed concentration will be 15% total solids and evaporator discharge 50% total solids. The required evaporation is 135,500 lb./hr. for the 250 tons of pulp production.

. . . In most cases a comparison between investment and operating costs will show the most profitable number of effects

#### Selection of Number of Effects

Early in the mill engineering the number of evaporator effects must be decided. This would be done regardless of consideration to be given future expansion. The most important factor to be considered is the relation between capital investment and operating costs. There are other considerations such as physical room available, largest equipment practical to fabricate and transport to the site, ultimate vapor loading, and the quantity of steam and condenser water available. Any one of these could be the deciding factor but in most cases a comparison between investment and operating costs will show the most profitable number of effects and, if sufficient capital is available, that course should be followed.

The direct operating costs include labor, steam, water, power, and maintenance. For this type of equipment a comparison of operating costs is usually confined to steam costs since labor demand does not change with a change in the number of effects and condenser water, power costs, and maintenance do not vary appreciably.

An estimation of the steam economy for an evaporator may be made by assuming each effect will do 0.85 pounds of evaporation per pound of live steam. Hence, a quadruple effect with normal economy accessories would have an economy of 0.85 × 4 = 3.4 pounds evaporation per pound of steam. By the same calculation we would estimate the steam economy of a quintuple effect at 4.25, a sextuple at 5.1, a septuple at 5.95 and an octuple at 6.80.

A common method of evaluating operating cost versus investment costs is the payout method. The cost of additional effects is divided by the annual steam savings to arrive at the

years required to pay off the investment. The payout period may be further modified by dividing the years by a decimal such as 0.48 to compensate for a 52% corporate income tax. Jelen (2) suggests capitalized cost as a method for comparison of alternatives. This method will be used to examine the evaporator economy of the imaginary mill proposed above, ignoring all other considerations. The design evaporation rate was 135,500 lb./hr. We will investigate only those systems normally considered for this capacity, namely quadruple through septuple effects. Evaporator costs are given on an installed basis, assuming outdoor installations. Annual steam savings are computed for a steam value of \$0.50 per thousand pounds and operation 8400 hours per year. Money is assumed to be worth 8%.

The total capitalized cost will be calculated as the sum of the equipment investment capitalized using K = CF<sub>m</sub> and the annual operating cost capitalized using K = MFm. Life of the equipment is taken as 10 years since at that time the mill will reach ultimate capacity. The capitalized cost of a uniform annual expense M-in this case the steam cost-can be regarded as equivalent to annual replacement of a unit costing that amount. The annual steam saving of a septuple over a sextuple may be regarded as an annual expense for the sextuple since it is the penalty paid for the use of less effects. Although seven effects are the largest number of effects presently used in this industry, an annual yearly expense for the septuple is capitalized on the basis of a theoretical octuple economy of 6.80. Table 1 summarizes these calculations and shows that for this case the sextuple effect is the best investment on the basis of investment versus operating

It is now established that our example mill can ultimately justify a sextuple effect evaporator. The capital may not be available initially to install a sextuple but the mill designers should anticipate the steps necessary to reach this goal.

#### Unplanned expansion

Faced with the problem of limited capital, the mill decided to install a quintuple effect evaporator. They know from the above evaluation that a sextuple is economically justified but must settle for a quintuple and resulting higher operating costs. They established the steam pressure at the available 50 lb./sq. in. gauge. Condenser vacuum is set at the usual 26 in. Hg.

A conventional quintuple effect evaporator with 24 ft. long tubes is purchased to meet these requirements. This evaporator would cost \$143,000. The evaporator would require 31,900 lb./hr. of 50 lb./sq. in. gauge steam. With steam at \$0.50 per thousand pounds, the steam cost would be \$1.53 per ton of pulp.

The first significant mill expansion would be made by adding a fifth digester. This would increase capacity 25% to 312 tons per day of pulp. Evaporator capacity must be increased 25% to 170,000 lb./hr. evaporation.

The required increase in capacity is difficult. Increased  $\Delta T$  can only be obtained by raising the steam pressure to a point where charring and resulting tube plugging are a problem. Sufficient increased surface for the new capacity can be obtained by lengthening tubes. This method is chosen with the realization that substantial downtime and loss of production will result from the change. Tubes are lengthened from 24 ft. to 32 ft. in the last four effects. An external heater is used on the first effect to avoid replacing the costly stainless steel tubes. These changes provide the required 25% increase in evaporation rate.

The installed cost of the tubes and first effect heater is \$48,000.

The evaporator capacity is now 170,000 lb./hr. and the quintuple effect will require 40,000 lb./hr. of 50 lb./sq. in. gauge steam and the steam

Table 1. Determining Economic Number of Evaporator Effects
Using Capitalized Cost Method

Effects	Quad.	Quint.	Sext.	Sept.
Steam Economy	3.40	4.25	5.10	5.95
Steam Req'dpph	40,000	31,900	26,600	22,800
Annual Steam Saving-3		34,100	22,300	16,000
Installed Evaporator Cost-\$	194,000	222,000	252,000	284,000
Capitalized Cost-CF10-8	823,000	715,000	686,000	695,000

cost per ton of pulp remains \$1.53

Installation of the sixth digester will increase pulp capacity to 375 tons per day. This requires another evaporator increase of 20%. The only method left to accomplish this is increasing the steam pressure to 65 lb./sq. in. gauge and adding external heaters.

The vapor handling capacity of the evaporator was initially set without regard to future capacity. As the capacity is increased, there will be increasing loss of  $\Delta T$  and capacity because of excessive pressure drop in the vapor handling system. This means we must increase the temperature drop by more than the direct ratio of required increase in capacity. Furthermore, some of the auxiliaries will be so badly overloaded that they must be replaced. The original pumps were specified at design rate plus a safety factor. New impellers or switching pumps will suffice in some cases but it will be necessary to replace the fourth effect transfer pump and the combined condensate pump. A larger condenser is needed. These changes again entail considerable downtime and production loss.

The installed cost of external heaters, new condenser, and revision to the pumps is \$70,000.

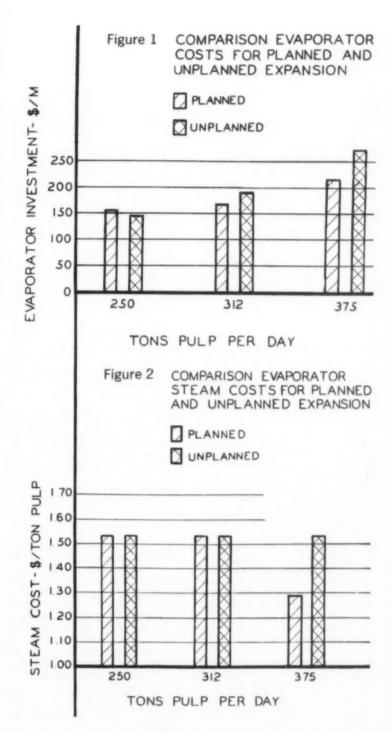
The evaporation rate is 203,250 lb./hr. The quintuple effect will require 47,800 lb./hr. of 65 lb./sq. in. gauge steam and the steam cost remains \$1.53 per ton of pulp.

The mill has found methods to reach 375 tons of pulp with the original equipment. To do this, they must satisfy themselves with continuing high operating costs and excessive entrainment losses.

#### Planned expansion

Initially management desires to provide evaporation capacity for 250 tons per day pulp at the lowest reasonable investment cost. They want the evaporator plant ultimately to provide for 750 tons per day but will want this final requirement handled by two separate evaporators. Two evaporators for 750 tons per day are preferred to provide flexibility of operation. Therefore, the initial evaporator system for 250 tons per day must be expandable to 375 tons per day. Management realizes this approach may result in high initial operating costs per ton of pulp and wants to reduce this with future planned expansions of capacity and increased number of effects.

It now becomes necessary to choose the method or methods to be applied to achieve future increases in capac-



ity. Whenever possible major physical changes to existing equipment should be avoided to prevent costly loss of operating time.

The minimum equipment changes are made if all capacity increases are

accomplished by increasing the  $\Delta T$ . This would mean an original design based on lower than available steam pressure and something less than the standard 26 inch condenser vacuum. The initial evaporator would have

more heating surface than normally required and would be more expensive.

Minimum first cost and maximum flexibility can be provided by designing with full steam pressure and condenser vacuum but installation of only enough surface to meet the initial requirement. Tube sheets would be completely drilled to receive the full complement of tubes required for future capacity. Sufficient tubes would be installed to provide the initial requirements for 250 tons of pulp per day. The remainder of the tube sheet holes would be capped. As increases in capacity are needed, the necessary caps would be removed and tubes installed.

All other components would be sized to handle the future capacity or arranged for easy conversion to greater capacity. The vapor handling system would be sized for future capacity since any changes would require major revisions to the equipment. The liquor pumps would be designed to permit future increased capacity by making a change in the impeller or motor.

Experience has shown that this delayed tube installation method provides the most flexible and least expensive approach to planned future expansions. The tube installations do not involve major physical changes to the evaporator or loss of production time.

The initial installation would be a quintuple effect evaporator utilizing 50 lb./sq. in. gauge steam and a condenser vacuum of 26 in. Hg. The vapor handling system would be sized to permit these bodies operating as the first five effects of the eventual sextuple unit for 375 tons pulp. This would avoid excessive vapor pressure losses when later used at the higher capacity. The evaporator would contain only sufficient tubes to provide the initial 135,500 lb./hr. evaporation but the tube sheets would be drilled for enough tubes to provide the future 203,250 lb./hr. of evaporation when operating as a sextuple. A quintuple effect evaporator of this design would cost \$155,000.

The quintuple effect would provide the required 135,500 lb./hr. of evaporation with 31,900 lb./hr. of 50 lb./sq. in. gauge steam. If steam is valued at \$0.50 per thousand pounds, the steam

cost will be \$1.53/ton pulp.

As previously noted, the first significant expansion will occur at installation of a fifth digester. The capacity can now be set at 312 tons of pulp. This will require an evaporator capable of 170,000 lb./hr. evaporation.

This first expansion step will be met by the installation of sufficient additional tubes in all effects to provide the required 170,000 lb./hr. evaporation when operating as a quintuple. The additional tubes would cost \$12,-000 installed.

The quintuple effect evaporation would provide the 170,000 lb./hr. of evaporation with 40,000 lb./hr. of 50 lb./sq. in. gauge steam. Steam costs remain \$1.53 per ton of pulp.

The installation of a sixth digester and increase to the 375 ton rate would require another evaporator expansion. The requirement is now 203,250 lb./hr. of evaporation. A sixth effect would be installed, together with sufficient additional tubes, to provide the required evaporation when operating as a sextuple.

The sixth effect and additional tubes would cost \$47,000 installed.

The evaporation rate of 203,250 lb./hr. will now require 39,800 lb./hr. of 50 lb./sq. in. gauge steam. Steam costs are now \$1.28 per ton pulp.

The increased evaporation has been provided while operating costs are reduced.

#### Benefits of planning

For the example problem it has been possible to expand evaporator capacity to 375 tons of pulp production with either the unplanned or planned approach. The bar graph in Fig. 1 illustrates the resulting investment costs. Steam costs are compared in Fig. 2.

The planned approach has, at the final expansion, provided the sextuple effect which early analysis showed was justified. The planned design has assured good operating characteristics due to properly sized auxiliaries and vapor handling system. In contrast, the unplanned system resulted in a quintuple effect with vastly overloaded auxiliaries and vapor handling system. The unplanned evaporator would require close operator attention and experience high chemical losses through entrainment.

Without planning it was necessary to retain the original quintuple effect system because of space and temperature drop limitations so steam economy remains constant through the various expansion steps. The planned system started with a quintuple—accepting high initial steam costs in order to reduce the first investment. Planned expansion to a sextuple improved the steam cost figure.

The importance of this steam saving is not evident on the bar graph in Fig. 2. The unplanned system at 375 tons of pulp production will require \$1.53 worth of steam per ton of pulp. The equivalent figure for the planned sextuple is \$1.28. The difference of \$0.25 per ton is equal to \$93.80 per day or \$32,800 for a 350 day year.

The delayed tube installation used as a solution of the example problem has been used with success in the paper industry. Some of the other methods will work as well.

It is hoped this discussion of planned versus unplanned evaporator systems will demonstrate the importance and gains to be made with the planned approach. The example used is similar to many encountered. In many cases the unplanned evaporators cannot be expanded to meet requirements even at the expense of increased operating costs. Early and careful planning of an evaporator can assure continuing operating efficiency while providing the future expansion charted by management.

#### Notation

A = square feet of heat transfer surface

C = initial cost, dollars

$$F_m = factor \frac{(1+i)^m}{(1+i)^{m-1}} = (1+G_m)$$

$$G_m = factor \frac{1}{(1+i)^{m-1}}$$

i = interest rate, decimal per year
 M = annual operating cost, dollars

M = annual operating cost, dol m = service life, years

 $\Delta P$  = pressure drop, inches of mercury Q = quantity of heat to be transferred,

BTU's per hour

ΔT = temperature difference impressed across surface, °F.

U = heat transfer coefficient, BTU's per square foot surface per °F per hour

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# Continuous solute removal from aqueous solutions

The means used to reclaim water in a growing chemical industry can make the difference between profit and loss. Here is a report of a cyclonic equilibrium stage for solute removal from high concentrations at high flow rates. Used in place of a fixed bed, with which it is compared, the cyclonic stage may make the profit-loss difference.

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W ITH THE INCREASING EXPANSION OF chemical plants and decreasing sources of available water, the reclamation of waste water serves the twofold purpose of conserving water and mini-mizing pollution. The major operations for this task involve evaporation, precipitation, bacteriological decomposition and various extractive methods. The recent introduction of adsorption on ion exchange resins in fixed beds suggests a new unit operation which has been shown to be effective for the removal of contaminants from dilute solutions. This operation is not of an ion exchange type, which requires a continuous supply of regenerant, but rather, it is of the adsorption type, in which the regeneration step involves the use of a solvent which can be reclaimed.

For industrial waste streams containing traces of organic constituents, the fixed bed type of operation is recommended; whereas for streams containing relatively high concentrations, and requiring relatively high flow rates, a continuous process offers the following advantages over the fixed bed operation (9): effective use of the regenerant, less resin inventory, more compact equipment, and independent design of the adsorption and desorption sections.

Continuous adsorption operations may be handled through the use of fluidized beds, countercurrent plugflow and equilibrium stage contacting. Hiester and Phillips (9) and Hutcheon (12) present an excellent review of these continuous systems.

Inherent difficulties in a fluidized bed operation result from ineffective contacting between a countercurrent flowing liquid and a sustained solid. These difficulties follow from the small density differences between resin and solution, attrition of moving solid, separation of the solid and liquid phases, and proper distribution of both phases throughout the contactor. The most serious of these obstacles is the limiting solution flow rate beyond which carry-over of the resin results. Equally serious is the requirement that an extremely favorable equilibrium must exist. If the equilibrium is not favorable, then a plug-flow type of operation is required.

A number of investigations dealing with the plug-flow type of operation have been carried out (8, 10, 14). All these investigations show the following characteristic limitations:

 limited liquid flow due to high pressure drop and possible fluidization of resin

2. channeling of liquid and resin phases (backmixing)

3. contamination of solution and regenerant

4. kinetic limitations due to large resin particle sizes

5. attrition of resin

In the development of a countercurrent equilibrium stage process, a liquid-solid cyclone has been employed to represent the equilibrium stage. Although this mode of operation is mentioned in the patent literature (5), no actual process data for this adsorption scheme are presently available. The

#### . . . Advantages of using cyclone as the equilibrium stage

proper design of liquid-solid cyclones is presented by Moder and Dahlstrom (13), who have extensively investigated the separation of different sizes and densities of polystyrene beads from liquids of varying densities.

The use of a cyclone as the equilibrium stage has the following advan-

1. relatively unlimited liquid flow rates due to substantial decrease of pressure drop

2. absence of channeling of both liquid and solid phases

 possible use of small particles of resin to produce increased rates of adsorption

These three advantages offset disadvantages 1, 2, and 4 encountered in the plug-flow operation.

In comparison with the fixed bed operation, the countercurrent cyclone equilibrium stage offers the following additional advantages:

 reduced resin inventory based on comparable liquid flow rates and rate of solute removal

2. uniform compositions of adsorption and regenerating effluents

The use of cyclones would require that the resin possess high adsorption capacities. At present, the majority of commercial resins possess unfavorable equilibrium relationships to render them adaptable for equilibrium stage contacting. This situation may improve with the introduction of new resins possessing higher adsorption capacities. Attrition and contamination are also inherent limitations with the use of cyclones.

#### Outline of the investigation

An analycis of the design aspects of the cyclonic type of operation must include equilibrium, kinetic, and operational studies. These were carried out with attention to the adsorption phase. For a broader background, equilibrium studies must be extended to include systems possessing high and low adsorptive capacities. In these studies the system phenol-water-Dowex-2 (Cl-) was selected as representative of highly favorable equilibrium, and the system aniline-water-Dowex-2 was chosen to represent the less-favorable case.

#### Equilibrium studies\*

To obtain the aniline and phenol equilibrium data of this investigation on Dowex-2 (Cl-) resin, a batch of 20-50 mesh size of the resin was thor-

oughly washed with water and then vacuum dried to remove the excess interstitial water. Measured volumes of either aqueous phenol or aniline solution were added to small bottles containing a weighed amount of the resin. The bottles were then sealed and shaken for 24 hours at room temperature (24-25°C.). The equilibrium solution was analyzed by refractive index measurements and found to remain unchanged after a three-day period. Two representative samples of the vacuum dried resin were completely dried at 90°C. for 24 hours to enable the calculation of equilibrium relationships on a dry basis.

The respective weights of phenol and aniline adsorbed per unit weight of dry resin were calculated by the expression:

$$y = \frac{V (x - x_o)}{m}$$

where y = grams of solute adsorbed/gram of dry resin, at equilibrium,

<sup>o</sup> Experimental data available in the literature for the adsorption of phenol on anion exchange resins are limited to the data of Anderson and Hansen (1) and Chasanov, Kunin and McGarvey (4). The adsorption of phenol on Dowex-1 (Cl<sup>-</sup>) resins is reported by Anderson and Hansen up to concentrations of 7 weight percent; whereas the equilibrium values of Chasanov et al. have been limited to phenol concentrations of less than 0.5 weight percent on Amberlite IRA-411 (Cl<sup>-</sup>) resin. No experimental data on aniline systems with anion exchange resins are currently available in the litera-

x= grams of solute/gram of solution. at equilibrium,  $x_o=$  grams of solute/gram of solution, at initial conditions, V= volume of initial solution, m= grams of dry resin.

These calculated results are plotted in Figure 1 for both systems. The data for the aniline system correlate linearly; whereas the phenol data produce a non-linear relationship.

#### Kinetic studies

To determine the retention time requirement for each equilibrium stage, the establishment of adsorption kinetics was essential. The use of a cyclone was thought to be comparable to that of a stirred batch reactor, in which liquid film contributions become negligible at high agitation speeds. With the elimination of liquid film resistances, this study reduces strictly to one of a diffusional nature, an experimental technique well defined in the literature (11, 16).

The experimental procedure was carried out as follows: Into a beaker containing a weighed amount of resin, dried at 90°C., a variable speed electric stirrer was positioned. A measured quantity of either phenol or aniline aqueous solution was poured into the beaker. The stirrer and a timer were then started, and liquid samples of 0.1 cc were withdrawn with a hypodermic needle at one-minute intervals. The mixtures were then allowed to stand for 24 hours to reach equilibrium, and in all cases the results agreed with the equilibrium relationships of Figure 1. Duplicate runs were carried out to check the reproducibil-

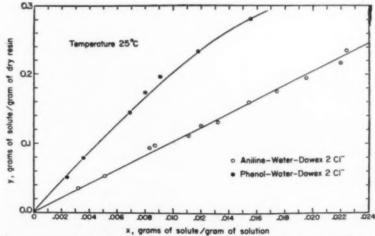


Fig. 1. Adsorption isotherms for the systems: aniline-water-Dowex 2 and phenol-water-Dowex-2.

ity of values. Four experimental runs of constant initial concentration were carried out to determine the critical agitation speed of the stirrer above which liquid film effects became negligible.

The results of these studies are presented in Figure 2 and show this to be 800 rpm. Consequently, the effect of initial concentration, particle size and type of solute were investigated at rotational speeds above 800 rpm. The rate of reaction was found to be independent of initial concentration as shown in Figure 3.

#### Evaluation of diffusion coefficients

The theory of diffusion into spherical particles from a stirred solution is presented by a number of investigators (2, 3, 6). Of these the most pertinent treatment is that of Crank (6), who uses the equations and solutions of Berthier (2) and presents a generalized solution in graphical form for diffusion in spherical particles.

With the elimination of liquid film resistances, the process of reaching equilibrium becomes strictly one of a diffusional nature, for which the following equation for diffusion through

spheres applies:

$$\frac{\partial C}{\partial t} = D \left[ \frac{\partial^2 C}{\partial r^2} + \frac{2}{r} \frac{\partial C}{\partial r} \right] \quad (2)$$

For the boundary condition existing when the sphere is initially free from solute, and also that the rate of diffusion of solute into the sphere is always equal to the rate of solute disappearance from the solution, Crank presents for the solution of Equation (2) the following expression:

$$\frac{M_{\tau}}{M_{\infty}} = 1 - \Sigma \frac{6\alpha(\alpha+1)}{9(1+\alpha) + \alpha^2 q_n} \varepsilon - \frac{(3)}{\frac{n^2}{\alpha^2}}$$

where:  $a = \frac{3V}{4\pi a^3}$ ; the ratio of the

volumes of solution and spheres and q<sub>n</sub> = the non-zero roots of Equation  $q_u = \text{the non-scale}$ (4). The ratio  $\frac{M_\tau}{M_\infty}$  represents the

fractional uptake of solute in the spherical particle at time, t. Berthier (2) presents tabulated values for the ratio,  $\frac{M_{\tau}}{M_{\infty}}$ , which have been plotted

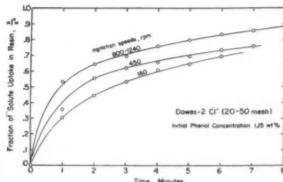


Fig. 2. Effect of agitation speed on rate of adsorption.

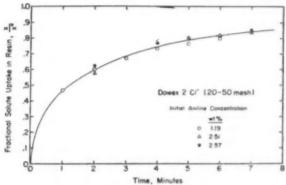


Fig. 3. Effect of initial concentra-tion of solute on rate of adsorption.

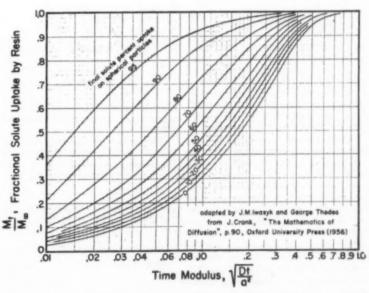


Fig. 4. Fractional solute uptake by spherical particles from a stirred solution of limited volume.

by Crank (6) and are reproduced in Figure 4.

$$\tan q_n = \frac{3q_n}{3 + \alpha q_n^2} \tag{4}$$

The diffusion coefficients, D, for a number of experimental cases have been determined by the use of Figure 4 and are presented in Table 1. A review of the results presented in Table 1 shows that the diffusion coefficient is essentially independent of particle size and initial solute concentration. These results also show that the diffusion coefficient for aniline is higher than that of phenol.

#### Operational studies

Since the batch adsorption kinetics for the removal of aniline and phenol from aqueous solutions with Dowex-2 (Cl<sup>-</sup>) resin were found to be favorable, operational studies were carried out to investigate the feasibility of a continuous equilibrium stage. The selection of proper equipment for the continuous equilibrium stage was dependent on the following factors:

- 1. proper cyclone design to insure solid-free overflow
- 2. pump capable of handling a slurry with minimum attrition and adequate liquid head
- 3. reliable metering of streams entering and leaving stage
- 4. adequate control of solution content in underflow resin stream

Figure 5 shows a diagram of the equilibrium stage employed in this investigation. The cyclone separator shown in this figure was constructed from Pyrex glass according to the procedure outlined by Dahlstrom (7). When tested, this cyclone proved adequate for handling resin sizes of 20-50 mesh and produced essentially a solid-free overflow. The slurry pump used was a Gormann-Rupp all-rubber centrifugal pump, capable of delivering 8 gal/min at two feet of head. No other agitator was used. The overflow stream flow rate was sufficient to keep the resin suspended in the solution.

The accurate metering of the streams entering and leaving the stage was essential for obtaining steady state conditions. The liquid steam rates were easily controlled with proportionating pumps. Slurries containing less than 60 to 70% resin are quite mobile and easy to handle; whereas higher solid concentrations render the slurry sticky and difficult to control. Several devices for metering slurries are reported in the literature (9, 12). Of these, several proved quite inadequate to this study, with the exception of a metering screw conveyor.

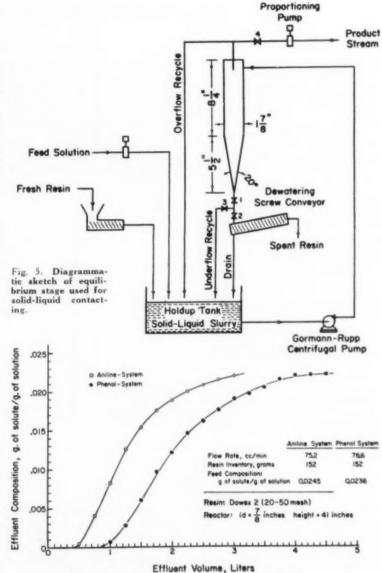


Fig. 6. Breakthrough curves for the adsorption of phenol and aniline.

This device proved capable of metering not only dry resin, but also resin slurries.

The success of this operation depended on the proper dewatering of the spent resin stream to a value which would produce negligible backmixing. The screw conveyor proved quite adequate in dewatering the underflow stream from the cyclone and became more effective when the conveyor was tilted upward to allow for liquid drainage. With this arrangement, the underflow stream leaving

TABLE 1. SUMMARY OF CALCULATED DIFFUSION COEFFICIENTS
FOR DIFFERENT OPERATING VARIABLES

System			Particle Size	Initial Concentration of Solute, wt %	D, Diffusion Coefficient, cm <sup>2</sup> /sec	
Aniline Water	Water	Dowex-2	20-50 mesh 20-50	1.19 2.57	8.34 x 10 <sup>-8</sup> 8.0	
			50-100 50-100	1.15 2.57	8.34 7.34	
Phenol	Water	Dowex-2	20-50	1.15	5.34	

the cyclone could be upgraded from 50 to 77% solids. After a typical experimental run, account was made of the solution leaving with the spent resin. This permitted adjusting the product stream rate to be set so that the feed solution to the stage would equal the sum of liquid quantities leaving in the product stream and the solution retained by the spent resin. This type of operation resulted in a constant holdup solution volume. The most sensitive part of this operation was the initial startup of the metering screw conveyor which, once properly adjusted, would continue to function dependably during the course of the run. Analysis of the product stream by refractive index measurement determined the amount of solute adsorbed by the resin. With the solidliquid contacting stage, runs were confined to the aniline-water system using Dowex-2 resin of 20-50 mesh size.

### Single stage operation

Runs were carried out to provide specific information on the following items:

 Significance of the liquid film resistance on the adsorption rate mechanism in the equilibrium stage

Confirmation of expected extent of adsorption in the equilibrium stage as predicted from equilibrium and diffusional data

3. Amount of solution retained in spent resin stream

Table 2 presents the results of a typical run for a single stage. For the initial part of the run when the overflow and underflow streams were completely recycled for thirty minutes, the solute concentration was found to remain constant at 0.0160 grams aniline/gram of solution. This value compares favorably with the value 0.0159 grams of aniline/gram of solution as predicted from Figure 1, using the

same ratio of 
$$\frac{L}{R} = 18.5$$
.

Reactor calculations based on constant composition can be used by assuming a uniform slurry in the

holdup tank and the cyclone. This condition is approximated from the experimental results of the cyclonic stage and the calculations based on batch reaction kinetics. These are indicated in the results of Run 3 presented in Table 3. The diffusion coefficient for aniline as determined from stirred reactor data, D = 8.0 x 10-8 cm<sup>2</sup>/sec, was used to predict a composition of 0.0174 grams of aniline/gram of solution after a retention time of 7.5 minutes. The material balance presented in Table 2 for this run shows good agreement between the incoming and outgoing streams, a necessary requirement for steady state conditions. The elimination of a liquid film resistance is due to the presence of high shear effects in the cyclone. To graphically represent the operational characteristics of a continuous adsorption stage of this type, it was necessary to account for the solution retention in the spent resin stream. Table 2 shows this value to be 23 percent for 20-50 mesh resin.

### Fixed bed operation

To broaden the background developed for the solid-liquid stage, investigations were carried out in fixed beds for comparative purposes. Experimental runs were carried out in a % inch i.d. glass column packed with 20-50 mesh Dowex-2 resin to a height of 41 inches. A feed solution flow rate through the column of 78 cc/min (4.26 gallons/min ft2) was used for the aniline and phenol systems. These conditions of resin size, height of bed and flow rate represent comparable operating conditions used in commercial practice. Refractive index measurement of the effluent streams established the composition and consequently the extent of adsorption of these runs. The breakthrough curves for the phenol and aniline systems are shown in Figure 6. Phenol began to appear in the effluent stream after 12.5 minutes of operation. The entire bed became ineffec-

Table 2. Results Obtained From the Operation of a Single Cyclonic Equilibrium Stage (Run 3)

A. Initial Operation (Closed System) Time of recycle = 30 minutes

L = 1500 cc of solution R = 81 grams of resin  $\frac{L}{R} = 18$ .

Solute Concentration, grams aniline/gram of solution Initial = 0.0244 Final (experimental) = 0.0160Final (Figure 1 prediction) = 0.0159

B. Continuous Operation: Time of Operation = 44.5 minutes

### Contents of Holdup Tank

	Tiescotte	T Dibert
Resin Solution L/R	81 grams 1500 cc 18.5	87 grams 1414 cc 16.3
	Flow Rates	

Feed Solution
Fresh Resin

192 cc/min
Spent Resin

10.8 grams/min
Spent Resin Stream
dry resin
interstitial solution

10.4 grams/min
6.5 cc/min

RESULTS OBTAINED FROM THE OPERATION OF A SINGLE CYCLONIC EQUILIBRIUM STAGE (Run 3)

adsorbed solution

Material	Balances
_	

9.0 cc/min

		Resin					Solutio	m		
Ing	out	O	utput			Input			Output	
Fresh Resin Holdup	= 481 grams = 81 562 grams	Spent Resin Holdup	= 468 grams = 87 555 grams	Fresh Holdu		= 8,554 gra = 1,500 10,054 gra	Re Ho	oduct Solutained Sol oldup		382
C. History of	Product Stream		8						99	16 grams
Time, minutes	ughput, liters	0	5.0 1.000	11.8 2.000	17.45 3.000	23.1 4.000	28.8 5.000	34.5 6.000	40.0 7.000	44.5 7.820
grams anilin	ne/gram of solut	ion0.01		0.0173	0.0177		0.0179	0.0177	0.0177	0.0177

Composition of total effluent stream: 0.0177 grams aniline/gram of solution

tive after 57 minutes. A sample of the total effluent for the run was analyzed and showed that 52.2 grams of phenol were adsorbed on the 152 grams (dry basis) of resin in the column.

### Countercurrent multistage operation

The results of a single stage countercurrent operation provide the essential background for a comprehensive analysis of a multistage scheme. The approach proposed by Treybal (15) is suitable for the projection of experimental information to the multistage countercurrent scheme of this operation. An analysis of the phenol system based on the following comparable operating conditions was made between a proposed continuous operation and a fixed bed operation.

1. Resin inventory

2. Feed solution flow rate

3. Product stream solute concentra-

Figure 7 presents a proposed flow sheet for the continuous process using a three-stage adsorption section and a three-stage regeneration section. The following assumptions were made for this process:

1. Negligible solution retention in the spent resin streams

2. Negligible attrition

3. Negligible carry-over of resin in the overflow stream

4. Insignificant holdup of resin in streams between stages

Insignificant carry-over of regenerative fluid into adsorption section

6. Batch reactor conditions

For the fixed bed operation, the following assumptions were made:

1. Complete removal of adsorbate with the regenerating fluid

2. Negligible retention of the feed

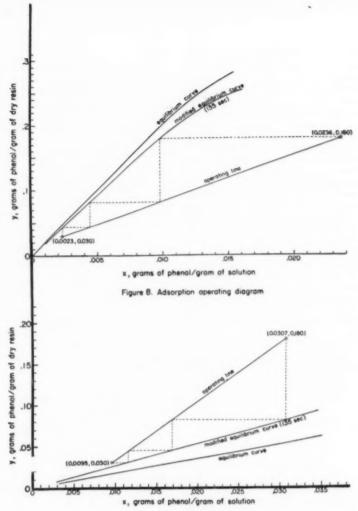


Figure 9. Regeneration operating diagram

solution and regenerating fluid in the beds between cycles

3. Resin size in fixed bed operations is limited to 20-50 mesh and flow rate of 4.26 gal./(min.)(sq.ft.), to represent comparable operating conditions used in commercial practice.

With these assumptions, the results presented in Table 3 were determined by use of the operating diagrams presented in Figures 8 and 9.

The comparison of these results shows significant advantages in favor of the continuous system as reflected

### TABLE 3. COMPARISON OF CONTINUOUS AND FIXED BED OPERATIONS

- A. Operating Conditions Used for Continuous and Fixed Bed Operations

  - Total Resin Inventory 152 grams
     Fresh Feed Solution 78.6 cc/min
  - 3. Stream Compositions:
- (a) Initial Feed 2.36 wt % phenol (b) Product Stream 0.23 wt % phenol

### Fixed Bed Operation

Particle size: 20-50 mesh

Time cycle: adsorption = 24 min, regeneration = 20 min Phenol adsorbed = 40.8 grams

Rate of phenol removal = -- = 0.928 g/min44

Regenerating fluid (methanol) = 1590 grams

Average phenol concentration in regenerating fluid = 2.52 wt %

### Countercurrent Continuous Operation

Particle size: 100 mesh

Time of operation = 44 min

Phenol adsorbed = 74.0 grams

Rate of phenol removal = = 1.67 g/min

44

Regenerating fluid (isopropyl ether) = 534 grams Phenol concentration in regenerating fluid = 3.07 wt %

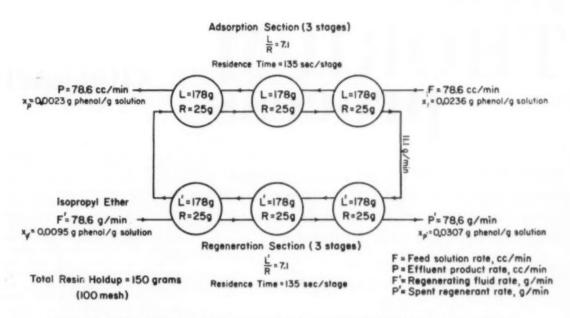


Fig. 7. Continuous adsorption-desorption cycle for the removal of phenol from aqueous solutions.

by increasing the rate of solute removal, phenol concentration in the regenerating fluid, and decreasing the quantity of regenerating fluid. These advantages are primarily due to the use of smaller particle sizes, which are feasible in the continuous operation presented in this study. Consequently, this scheme merits further study in the development of the cyclonic stage operation.

The results of this investigation show that the cyclonic equilibrium stage provides a more effective solute removal than the fixed bed for:

1. Tenfold reduction of solute concentration

2. Existence of linear or favorable equilibrium curve

3. Attainment of 90 percent of equilibrium within less than four minutes of contacting for an average particle size of 100 mesh

### Future proposals

Further considerations of this process involve regeneration and attrition aspects. Theory predicts that the extent of solute removal in the adsorption section will depend upon the amount of adsorbate removed from the resin in the regeneration cycle. The amount of adsorbate removed in the regeneration cycle will be determined by the operating conditions,

equilibrium and kinetic characteristics of the regenerating fluid, and effectiveness of the distillation steps for the recovery of the solvent. For the removal of trace quantities of solute present in the product stream, a fixed bed may be used in conjunction with the continuous system.

Future studies should include equilibrium, kinetic, and attrition tests on 100-200 mesh sizes with DVB contents other than 8 percent. Preliminary attrition studies show that the slurry pump causes most of the particle disintegration. A thirty-day test

using one stage and a ratio of  $\frac{L}{R}$ 

20, with a particle size of 50-100 mesh, shows 7% breakup to a size under 100 mesh. Among other inherent operating difficulties noted, were in the metering of resin streams, and the maintenance of steady state conditions. These difficulties could be resolved with proper instrumentation.

The encouraging results of these studies suggest that the cyclonic equilibrium stage can be applied to other solid-liquid contacting operations such as leaching, ion exchange, and liquid phase catalytic reactions.

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# new THORIUM process

Although the results do not permit immediate industrial application of such high temperature processing, the technology presented here probably is

R. C. Reid<sup>1</sup>, S. H. Jury<sup>2</sup>, J. C. Bresee<sup>3</sup>, and J. C. Suddath<sup>3</sup>

sufficiently novel to warrant further study.

N BOTH GOVERNMENT AND INDUS-TRIAL laboratories considerable interest is being shown in developing methods for preparing pure thorium metal. This interest stems from the fact that thorium is a fertile element and can be converted to fissionable uranium-233 by neutron irradiation. Irradiation techniques vary and the thorium may be irradiated in either the metallic or non-metallic form; for example, metallic elements would be preferable when a definite structural shape is desired but in the Homogeneous Thorium Reactor (HTR) proposed in the AEC's 5-year plan, it is intended to use a thorium oxide slurry as a blanket material.

### Review of Previous Publications

Many current investigations dealing with the production of thorium metal are still classified. Glasstone (4) has summarized the published methods which include the reduction of thorium tetrachloride or tetrafluoride with an active metal such as sodium, calcium, or magnesium. Ordinarily, a bomb reduction technique is used but the high melting point of the product thorium makes it difficult to obtain a

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<sup>1</sup> Dept. of Chemical Engineering, University of Tennessee, Knoxville, Tenn. <sup>1</sup> Oak Ridge National Laboratory, Oak Ridge, Tenn. compact thorium mass. Zinc may be added to the reduction melt to reduce the thorium melting point, but this zinc must then be subsequently removed by a vacuum distillation.

In 1955 the Kennecott Copper Corporation was granted a patent (3) on the sodium amalgam reduction of thorium (and other metal) halides. There are several advantages in carrying out such active metal reductions in the presence of mercury; that is, the reducing agent is easier and safer to handle, the mercury often prevents any oxidation of the reduced metal by either coating or amalgamating with it, and the diluent effect of the mercury allows some control of the reaction. There are a number of ways in which thorium salts could be contacted with such a sodium amalgam but it is not possible to discuss most of these methods here. Ideally, the salt and sodium should be contacted in a homogeneous phase to attain rapid reaction rates but so far as is known, there are no solvents for both the dry salt and sodium amalgam

One possible solution to the solvent problem would be to carry out the reaction at such an elevated temperature that the sodium, thorium feed salt, and diluent mercury are all present as vapors. After reaction and cooling, the product thorium should amalgamate with the condensed mercury, a step which would allow easy handling and separation of the thorium.

# vital metal

A literature search on vapor phase reactions involving sodium indicated that this type of reaction has not received much attention. Lely and Hamburger (7) contacted thorium tetrachloride and sodium in a bomb and the reaction temperatures were sufficiently high to vaporize some of the sodium, but apparently the extreme reactivity of sodium in the solid, liquid, or dispersed state has not encouraged many investigations of the re-activity of sodium vapor. This report describes the results of an experimental investigation of the vapor phase reaction of ThCl, with sodium and indicates the problems encountered in carrying out such a hightemperature gaseous reaction. Although the results do not permit any immediate industrial utilization of such a high temperature metallurgical process, it is believed that such technology is sufficiently novel that the results may prove their worth in encouraging more study on this reaction or in other similar high temperature

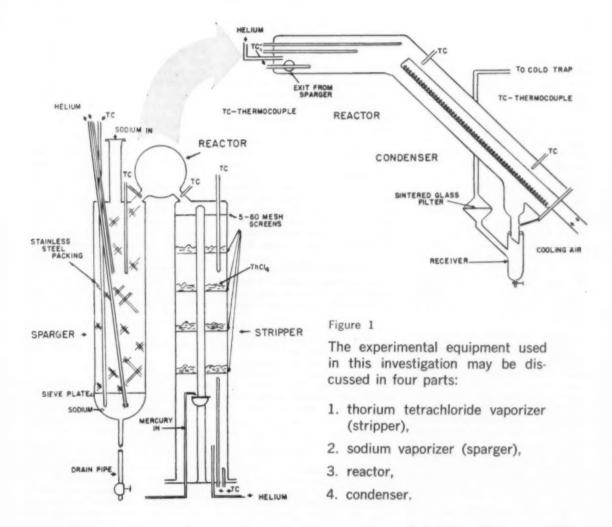
### Vapor phase reduction

The vapor phase, high temperature sodium reduction of thorium tetrachloride was investigated and the results are presented here.

Mercury vapor acting as a carrier for sublimed thorium tetrachloride was contacted with sodium vapor, diluted with helium. The products when cooled were noted to consist of nearly equal amounts of a solid powder phase and a phase which appeared to be clean mercury. Thorium, sodium, and chloride were found predominantly in the powder phase.

Both phases were washed with 3 N HC1 and water. Thorium was distributed as a filterable quasi in the mercury phase, as dissolved thorium in the acid wash, and as a powder which was not wettable with mercury nor soluble in HC1. Analytical data indicate that a large fraction of the thorium in the product was present as reduced metal. The data

# for industry and defense



also indicated that the vapor pressure of ThCl<sub>4</sub> in an impure feed salt was much lower than would have been anticipated from vapor pressure data of the pure salt. Corrosion of the equipment resulted in iron, nickel, and chromium contamination of the product.

### Thorium Tetrachloride Vaporizer (Stripper)

Pure thorium tetrachloride melts at 770°C, and boils around 922°C. (8). The salt which was available for this investigation was not pure and contained some thorium oxide and oxy-

chloride. Consequently, a subliming technique was used to strip the pure thorium tetrachloride from the contaminating thorium oxide and oxychloride. Mercury vapor was chosen as the stripping gas.

The stripper consisted of a 30-inch long by 4-inch i.d., Type 347, stain-

### . . . Sparger heated with clamshell heaters

less steel pipe (See Figure 1). A blind flange was attached to the bottom and the top closed off except for a 1-inch i.d. pipe leading to the reactor. Welded to the bottom flange was a vertical rod which extended almost to the top of the stripper. Attached to this center rod were five circular (and slightly conical), 4-inch, 60 mesh screens, Type 347, stainless steel. The screens were 3 inches apart and were used to hold the impure thorium tetrachloride feed. (The top screen was not loaded but was used as a filter.) The screens each held between 100 to 200 grams of feed salt.

Liquid mercury was injected into a small cup below the screens. Flash vaporization occurred and the superheated mercury vapor passed up through the screens stripping the volatile ThCl<sub>4</sub> from the non-volatile ThOCl<sub>2</sub> and ThO<sub>2</sub>. The upper 24inches, including the screens and mercury boiling cup, was maintained at a high temperature by three 8-inch clamshell electrical heaters around the pipe. The lower 6 inches and flanged section were kept above the boiling point of mercury but not as hot as the upper section, since high-temperature gasket materials are not reliable. (Asbestos with a very thin coating of graphite was used here.)

### Sodium vaporizer (sparger)

Sodium has a higher vapor pressure than thorium tetrachloride when compared at the same temperature. Thus, even though four moles of sodium must be vaporized per mole of thorium tetrachloride, actually a lower vaporization temperature may be used without introducing excessive quantities of the carrier gas. In theory, the sodium sparger was similar to the thorium tetrachloride stripper except that at volatilization temperatures, sodium is a liquid whereas thorium tetrachloride is a solid.

The sodium sparger (See Figure 1) consisted of a 24-inch section of 4-inch, i.d., Type 347 stainless steel pipe closed at the bottom by a cap. A drain line was connected to the bottom of the cap. Sodium addition was made through a standpipe at the top. The top section of the sparger was filled with 3/8-inch stainless steel Raschig rings. These rested on a sieve plate below which was the cap containing the sodium. The packing decreased the probability of liquid so-

dium carryover. Two helium lines were fitted into the sparger. One which extended almost to the bottom was fitted with a diffuser head and used to sparge out the sodium vapor. The other line extended about half-way down and was used to blanket the sparger when the first line was sealed shut by solidified sodium.

The sparger was heated with clamshell heaters in the same manner as the thorium tetrachloride stripper.

### Reactor

The reactor, Figure 1, consisted of an 18-inch horizontal section of 4-inch i.d., Type 347 stainless steel pipe. The vapor feed streams from the stripper and sparger entered from the lower sides at one end of the reactor at an angle of 90°. Heat was supplied to the reactor by clamshell heaters. An emergency helium coolant stream was connected near this entrance in case the reaction temperature should exceed safe limits. This cooling inlet was never used, since reaction temperatures were satisfactorily controlled by varying the input to the heaters.

### Condensing section

The condensing section, Figure 1, consisted of a 24-inch long, 4-inch i.d., Type 347 stainless steel pipe at-

tached to the exit end of the reactor at an angle of 45°. The downstream end was closed by a blank flange through which a nickel coil was inserted. Compressed air blown through the coil cooled the condenser. The cooling coil was made of nickel instead of stainless steel to yield an amalgamated, uniformly-wetted cooling surface to aid in washing out the products of reaction.

The cooled reacted and unreacted materials were drained through a 3-inch pipe near the bottom of the condenser. (Any liquid collecting below this point was drained out through a hole drilled in the flange proper.) The helium was separated from the solid and liquid product in a collector, the helium passing through a coarse fritted glass filter and cold-trap before being vented.

### The method

The system was leak-tested and blanketed with helium. Sodium (about 1.25 lbs.) and thorium tetrachloride (about 600 grams) were added and the heaters turned on. After several hours steady temperature readings were obtained. To start a run, mercury and sparging helium were simultaneously introduced into the system and maintained at a constant rate throughout the run.

Some difficulty was experienced in collecting product, since even at very high mercury rates, a powder was ob-

TABLE I EXPERIMENTAL CONDITIONS

n		ture – °C.	Average Mercury Rate	Average Helium Rate	Duration of run	
Run		Sparger	grams/sec.	cu. ft./min.	minutes	Remarks
A	700	650	1.00	0.33	30.0	Receiver, packed with glass tubes, plugged after 30 minutes.
B	700	650	1.28	0.20	25.3	
D	700	650	1.46	0.20	57.9	No cooling air in con- denser section. Tem- perature downstream about 225°C., up- stream about 275°C.
Е	750	800-900	1.47	•	30.0	No cooling air in con- denser. Helium line to bottom of spar- ger plugged. Sodium boiled up and car- ried over by upper helium line.
H	850	800-900	1.48		30.0	See remarks on E.
G	850	800-900	1.45	•	9.0	See remarks on E. However, higher he- lium rates were used. Severe plug- ging occurred with formation of solid product.

<sup>·</sup> Unknown

tained in addition to a liquid mercury phase.

During the highest temperature runs, the helium line leading into the bottom of the sparger became plugged, probably with scale or so-dium oxide. To obtain sodium flow under such circumstances, the sodium in the bottom was boiled ( $T_b = 885^{\circ}\text{C.}$ ) and the vapors caught by the upper helium line and carried into the reactor. Although there was no control on the rate of sodium addition under these circumstances, the method worked quite well and at all times excess sodium was vaporized.

### Results

A summary of the experimental conditions is presented in Table I.

Analyses of ThCl<sub>4</sub> before and after stripping are shown in Table II. For reference the theoretical amounts of thorium and chloride present in ThCl<sub>4</sub>, ThOCl<sub>2</sub>, and ThO<sub>2</sub> are also given. As expected, the thorium concentration and percent insoluble increased and the chloride concentration decreased after heating since thorium tetrachloride was volatilized in the process.

The salt was chalky white when inserted into the stripper but was mud colored when removed. Mercury contamination was suspected and confirmed by analysis. The residual salt, after heating, had a fused appearance which was especially marked after runs E, H, and G in which the stripper temperature was maintained well above the reported melting point of pure thorium tetrachloride.

### Product washing and analysis

The product drained from the condenser and receiver during all runs was heterogeneous in physical appearance. Two physical phases could be distinguished: a clean-looking, liquid mercury phase and a black powder phase. The mercury phase poured easily and only wet glass slightly; the powder phase varied in texture between a "dry" fluidized powder and a claylike cake which had to be scooped out with a spoon. Examination of the powder phase with a 150power microscope revealed that it was composed of a large number of small. shiny mercury drops which were prevented from coalescing by a film of powder. The powder, in most cases, had little or no resistance to stress and, by stirring it carefully, coalescence of a large part of the mercury could be achieved. In most runs, samples of both the powder phase and mercury phase were taken for analy-

TABLE II
ANALYSIS OF FRESH AND STRIPPED THORIUM TETRACHLORIDE

Sample	Thorium percent	Chloride percent	Insoluble in Alcohol percent	Mercury percent
Feed for runs A, B, D	74.8	28.8	34.1	_
Residue from runs A, B, D	71.1	21.8	59.7	720 ppm °
Feed for runs E, H, G	58.4	34.2	28.4	-
Residue from runs E, H, G	72.6	5.77	91.3	14.7
ThCl <sub>4</sub>	62.0	38.0	0.0	
ThOCl <sub>2</sub>	72.7	22.3	100.0	
ThO <sub>2</sub>	87.9	-	100.0	

\*No trace of Hg++ found.

sis. Relative weights of both phases couldn't be determined experimentally.

The liquid and powder products were washed with 3 N HCl and deionized water to remove unreacted sodium and soluble salts. The mercury separated extremely rapidly from the powder phase when contacted with an aqueous (or alcoholic) medium. The acid and water wash liquors were quite dark in color but clarified when centrifuged, filtered, or allowed to stand for several hours, and a fine, black powder could be filtered from the liquors. The powder was not miscible with mercury (even when heated) nor was it apparently soluble in hydrochloric acid. However, solution was effected by concentrated nitric acid. Samples of this powder were also taken for analysis. The washed mercury phase was slowly filtered through coarse fritted glass filters, and in most cases a small quantity of concentrated thorium amalgam (quasi) was obtained. Both the quasi and mercury filtrate were analyzed. The acid wash liquors were green in color. Since some corrosion of the stainless steel was suspected, samples were analyzed for iron, nickel, and chromium. See Table III for analyses.

### Product quality

Thorium and sodium material balances on the powder and liquid phases of the product indicate that the powder phase amounts to between 20-60% of the total product weight. The actual weight of the powder phase could not be determined since complete separation was impossible. The estimation of the amount of powder was, however, important since it was in this powder phase that most of the thorium, sodium, and chloride were found.

From the reduction reaction, the product should (or may) have contained Th, Th\*\*\*\*, Na, Na\*, Cl-, Hg, and any materials resulting from corrosion of the equipment. Of most importance was a decision concerning

the state of the thorium found, that is, how much reduction took place.

The thorium carried out of the stripper was presumed to be pure ThCl<sub>4</sub>, since ThOCl<sub>2</sub> and ThO<sub>2</sub> are not volatile at the temperatures used. Neglecting any oxidation which may have occurred in the condenser or in the sampling, the thorium present in the product must have been either metallic or Th\*\*\*\* (in ThCl<sub>4</sub>). If all the thorium were present as ThCl<sub>4</sub>, it would have been completely dissolved by the acid and water washes, whereas only 40-60% was dissolved.

On the other hand, the thorium in the product may have been completely reduced and the thorium appearing in the acid resulted from dissolution of the finely divided thorium metal. The moles of HCl necessary to dissolve the thorium may be calculated as (4) moles thorium dissolved. The calculated loss in solution acidity may be compared to the true loss and the net difference attributed to unreacted sodium.

The difference between this calculated value of unreacted sodium and total sodium in the product should be equivalent to the sodium which reacted with the ThCl<sub>4</sub>. Since for each gram of sodium which reacts with ThCl<sub>4</sub>, 2.5 grams of thorium should be reduced, the data may be checked by comparing the calculated and experimental values of thorium. These values are compared in Table IV.

TABLE IV

Run	Th Calc.	Th Actual®	% of Actual
В	2.6	3.34	78
D	1.0	5.21	19
E	8.0	12.93	62
H	3.7	4.48	83
G	4.0	5.13	78

\*Neglecting thorium in powder filtered from acid wash.

Table III

### ANALYTICAL RESULTS

Run	B D	E	H	G
INITIAL WEIGHT OF PRODUCT = 820 g	ms 4720 gms	2276 gms	2178 gms	908 gms
ACID WASH = 400 II	al 2000 ml	450 ml	$450  \mathrm{ml}$	500 ml
WATER WASH = 400 m	al 1500 ml	400 ml	400 ml	200 ml

Sample	Run	Th	Na	Cl-	Hg	Fe	Ni	Cr	Remarks
		(ppm)	(ppm)	(ppm)	(%)		-		
POWDER PHASE OF	В	10,000	8100	12,500	_				
PRODUCT	D	-	-	-	4000				valid prod
	E	11,700	2900	7100	92.0			ť	ict analyses
	H	15,600	3100	7400	83.0				
	G	27,300	17,400	23,200	83.0				
		(ppm)	(ppm)	(ppm)	(%)				
LIQUID PHASE OF	В	430	-	_	_				
PRODUCT	D	-	_	-	-				
	E	112	260	< 25	99.9				
	H	130	20	< 25	99.9				
	G	368	770	62	99.9				
									20131
ACID, FRESH	В	_	_	_	whites				3.04 N
	D	-	_	-					3.16 N
	E	_	-	-	-				3.06 N
	H	-	_	-	-				3.02 N
	G	_	-	-	_				2.99 N
		(mg/ml)	(mg/ml)	(mg/ml)	(ppm)	(mg/ml)	(mg/ml)	(mg/ml)	
ACID, AFTER WASH	В	6.02	6.98	112	9	1.27	0.011	0.022	2.70 N
ACID, AFTER WASH	D	1.36	6.34	-	_	A	0.011	0.022	2.85 N
					_	1 26	15 nnm	68 nnm	2.66 N
	E	17.6	8.25	3.68 N			15 ppm	68 ppm	
	H	6.16	7.95	3.72 N	-	1.22		36 ppm	2.65 N
	G	6.26	23.2	3.16 N	_	0.13	<5 ppm	5 ppm	1.99 N
		(mg/ml)	(mg/ml)	(ppm)					
VASH WATER	B	0.088	0.074	_	_				0.023 N
VASH WAILER	D	0.013	0.06	-	-				0.02 N
	E	0.001	0.026	62	_				0.05 N
	H	0.024	0.025	67	_				0.06 N
	G	0.053							0.07 N
		(ppm)	(ppm)	(ppm)					
WASHED AMALGAM	В	1100	1	-	-				
	D	489	3	68	giote.				
	E	2200	3	<25	-				
	H	783	4	<25	_				
	G	2200	3	< 25	-				
		(ppm)	(ppm)						
Dan 1 000	В	10,160	12	_	-				
PEAU	D		43	_					
		2100							
	E	33,200	15	_	_				
	H	25,100	19	_	-				
	G	26,400	16	_	-				
		(ppm)	(ppm)	(ppm)	(%)				
MERCURY FILTRATE	В	760	3	_	-				
FROM QUASI	D	_	-	-	-				
	E	8	63	<25	99.9				
	H	69	3	< 25	99.9				
	G	31	3	<25	99.9				
			/		/#1	193	(npm)	(npm)	
99	T)	(%)	(ppm)	(ppm)	(%)	(%)	(ppm)	(ppm)	
POWDER FILTERED	В	14.1	200	-	75.7	1.03	96	574	
	D	12.6	180		73.4	0.46	203	335	
	E	7.45		<25	-	-	-	-	
	H	17.2	99	<25	_	_	-	-	
	G	19.0	253	< 25	_	-	-	_	

### EFFICIENCY OF STRIPPER

Calculated ......

Experimental .....

B

700

4.1

13

D

700

31

1.1

3.5

E

750

7.0 0.3

H

850

670

2.05

G

850

670

5.7

0.9

The check is not good. However, if the assumption that all thorium appears as the reduced metal is modified, e.g., to the assumption that it is present as a mixture of ThCl<sub>4</sub> and Th, a recalculation of the data by similar methods yields a poorer check. Further, an analysis of the product powder obtained from run E showed that the amount of thorium present as Th\*\*\* was only 21% of the total thorium present. It is therefore assumed that a large fraction of the thorium in the product was reduced to the metallic state.

Table III reveals that the thorium, sodium, and chloride are predominantly found in the powder phase of the product. Based on the remarks in the foregoing paragraphs, it appears likely that during reaction the finely divided solids which form on reaction (thorium and sodium chloride) tend to be coated by mercury during the condensation and form a powder which coalesces with difficulty. Some of the thorium undoubtedly combines with the condensing mercury to form an amalgam; in fact the evidence points to two types of amalgam formed; the first type is represented by the mercury-wettable variety which is filterable from the mercury phase as an amalgam (quasi); the second type is represented by a thoriummercury concentrate which has a high thorium concentration and is present as a relatively inert solid. This is suggested as the origin of the solid which is filtered from the acid wash. The thorium concentrations of the solid run between 7-22% and the mercury concentrations between 75-80%.

Little can be inferred about the distribution of the elemental sodium in the product although it is noted that it occurs predominantly in the powder phase.

### Efficiency of Stripper and Sparger

Runs B and D were made with a known helium rate and sparger temperature; thus it is possible to calculate the amount of sodium expected in the product for a run of a given length of time. Vapor pressure data indicate that for runs B and D, ratios of 5.1 and 4.4 grams of sodium per 1000 grams of mercury would have

been expected. Experimental values were 3.4 and 2.7, respectively. The efficiency of the sparger under these conditions appears to be around 60-

grams ThCl,

1000 grams Hg Feed

grams ThCl,

1000 grams Hg Feed

Stripper Temperature, °C .....

Per Cent Efficiency .....

It was not possible to measure accurately the thorium chloride residue after the runs, nor was it possible to determine any thorium accumulation within the reactor (although from examination of the condenser and reactor exit it appears that there was essentially no accumulation) so a thorium balance was made by comparing the calculated and experimental values of grams ThCl<sub>4</sub> in product per 1000 grams of mercury.

Contrasted to the efficiencies obtained with the sparger, the stripper operated very poorly. Even at a temperature of 850°C. (above the reported melting point of ThCl4), very little thorium was carried over. See Table V. This very same difficulty has been experienced before (1, 5) and temperatures around 900-1000°C. were necessary to allow even a moderate sublimation rate. There are indications from the scanty data of run A and those given above, that fresh ThCl<sub>4</sub> feed sublimes more rapidly than material which has been heated for any length of time. Possibly some sort of solid solution effect occurs between the various chlorides and oxvchlorides of thorium, the net result of which is a much lower measured vapor pressure of ThCl4 than would be predicted.

### Comments

Moderate corrosion of the apparatus was noted during the experimental work. The acid wash liquor was always green in color as a result of the presence of iron, nickel, and chromium chlorides; the powder filtered from the acid wash showed considerable iron and some nickel and chromium. No analyses for iron, chromium, or nickel were made on the washed amalgam.

Type 347 stainless steel was chosen for the material of construction al-

though quartz and other ferrous and non-ferrous metals and alloys were considered.

Ouartz could not have been used since it reacts readily with sodium (6) and with thorium tetrachloride (2, 9). The only ferrous metals stable in the presence of high temperature sodium belong to the high chromium stainless steel family. Of the non-ferrous metals, nickel, columbium, molybdenum, tantalum, chromium, and cobalt are reported to be resistant (6). Most high-temperature experiments conducted in sodium have been made in Type 347, columbium-stabilized, stainless steel. This material is reported to be resistant at temperatures as high as 900°C., although sodium oxide contamination in concentrations above 0.005% accelerates the attack by intergranular penetration. Type 347 stainless steel should be resistant to mercury but not much is known about its resistance to attack by thorium tetrachloride.

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This compound type may be stabilized by some iron, nickel, or chromium. See Table III.

# high capacity low temperature

# REFRIGERATION

Design characteristics of a custom-built refrigeration unit which operates under widely varying temperatures and cooling capacity requirements are covered in this article. The unit employs a cascade refrigerant system.

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This paper describes an installation which is of interest in the study of low temperature refrigeration. A high refrigeration load, with an unusually low temperature, created a number of unique problems.

The installation is at the Propeller Hub Altitude Test Facility, Air Research and Development Command's Wright Air Development Center at Wright-Patterson Air Force Base, Dayton, Ohio. The test facility involves a conditioned space for the simulation of altitude conditions, requiring control of both temperature and pressure over a wide range. A high velocity air stream in the test facility, past the propeller hub being tested, creates a relatively high refrigeration load, and the varying pressure and velocity conditions result in a wide variation in required cooling capacity and temperature.

The equipment supplied by the refrigeration contractor included the refrigeration plant, a system of brine piping and storage, and the test facility air cooling coils.

Rapid cooling of the test chamber to simulate the rapid climb of aircraft is a requirement necessitating cooling brine to as low a temperature as practicable. A brine cooling capacity varying from 120 tons\* refrigeration at -150° F to 375 tons at -92° F brine temperature is provided. This will give an air cooling capacity varying from 100 tons at -137° F to 350 tons at -75° F based on the temperature of air leaving the cooling coil.

Simulated altitude conditions vary from slightly below sea level to approximately 90,000 feet.

For the low brine temperature requirement of  $-150^{\circ}$  F, the use of

a single refrigerant throughout the many stages of compression is not practical. In the interest of economy, it is desirable to use a refrigerant having a relatively high vapor pressure for the lowest temperature condition, in order to keep the size of the compressor displacements within reasonable bounds. Refrigerant-12 (CC1<sub>2</sub>F<sub>2</sub>) and Refrigerant-22 (CHClF<sub>2</sub>), generally used for higher temperature operation, are limited to about

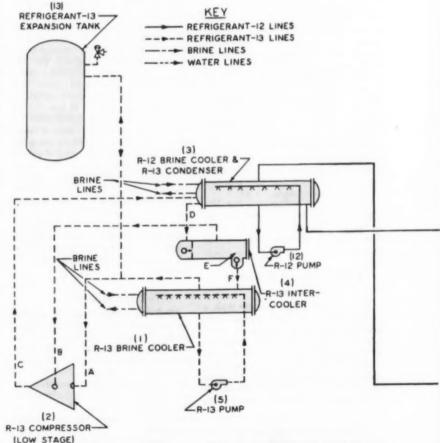


Fig. 1 Schematic refrigerant

A ton of refrigeration is equivalent to 12,000 BTU per hour heat removal rate.

-130° F evaporator temperature. At -130° F, the corresponding pressure of Refrigerant-12 is 0.41 psia and the CFM (actual) of refrigerant gas per ton of refrigeration is about 200. Refrigerant-13 (CC1F<sub>3</sub>), on the other hand, being a considerably higher pressure refrigerant, has a corresponding pressure of 9.1 psia and approximately 12 CFM of gas per ton refrigeration at -130°F. At the -157°F evaporator temperature required, the lowest condition of operation in this application, the suction pressure in the Refrigerant-13 system is 3.5 psia and the corresponding volume of gas flow is 29 CFM per ton of refrigeration.

Refrigerant-13 is used as a refrigerant in the lower stages only, since the normal condensing temperature of 100°F is above the critical point of the refrigerant. By limiting Refrigerant-13 to the lower stages of compression, the working pressure of the system will

not exceed the normal operating pressures of equipment designed for air conditioning duty.

For the higher stages of compression, Refrigerant-12 or Refrigerant-22, with relatively low working pressures, can be used with equipment designed for the normal pressure range. This arrangement, employing two separate refrigerants in elevating heat from low to high temperature, is known in the industry as a "cascade system."

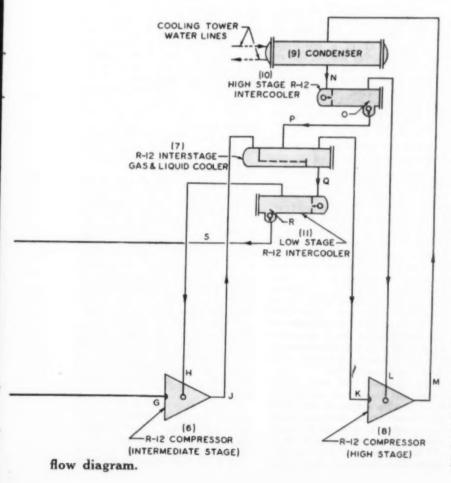
Figure 1 shows a schematic refrigerant flow diagram, indicating the major pieces of equipment and the more important flow lines required in a system of this type. Three centrifugal compressors are used to elevate the heat from  $-157\,^{\circ}\mathrm{F}$  evaporator temperature to a condensing temperature of  $104\,^{\circ}\mathrm{F}$  where the heat is rejected to cooling tower water. The low stage centrifugal compressor handles Refrigerant-13 and the two upper stages handle Refrigerant-12.

Low temperature brine, from the

air cooling coils, storage tanks, or both is circulated through the tubes inside the Refrigerant-13 brine cooler (1) where heat is removed by the evaporation of Refrigerant-13 liquid sprayed over the tube surface. The evaporated Refrigerant-13 gas is pumped by the low stage compressor 2) to condensing conditions established at the refrigerant cooled-refrigerant condenser (3). Here, the heat of condensation is removed by the low stage of Refrigerant-12 cooling. The refrigerant cooled-refrigerant condenser (3) consists of a shell and tube arrangement wherein the Refrigerant-13 gas is condensed inside the two pass tube bundle and the Refrigerant-12 liquid is evaporated in the shell. The Refrigerant-13 liquid condensed in the tubes flows by gravity to the Refrigerant-13 intercooler (4), equipped with float control expansion devices, from where it is fed to the Refrigerant-13 brine cooler (1). The expansion from condensing pressure to evaporator pressure is in two stages with the flash gas removed at some intermediate pressure to the third of four impellers in the centrifugal compressor (2). By removing the gas at this point, the compressor horsepower is reduced, since this gas need only be pumped from an intermediate pressure to condensing pressure.

A refrigerant circulating pump is a practical necessity in low temperature systems with large diameter coolers. The alternative design, with tubes submerged in liquid refrigerant, results in a refrigerant pressure increase, due to hydrostatic pressure of the refrigerant liquid, with a corresponding rise in effective refrigerant temperature—a serious penalty. Secondly, a considerably larger quantity of the expensive Refrigerant-13 would be required with a flooded-type brine cooler.

The heat of condensation given up by the Refrigerant-13 in the refrigerant cooled-refrigerant condenser (3) is absorbed by the evaporation of Refrigerant-12 on the shell side. Here again, the tube surface is wetted by the Refrigerant-12 circulating pump (12) through spray nozzles located above the tubes. The evaporated Refrigerant-12 is compressed by the intermediate stage compressor (6) to some intermediate pressure and temperature and is introduced into the Refrigerant-12 interstage gas and liquid cooler (7). Some of the superheat is removed from this gas by its contact with liquid refrigerant introduced by the higher stage intercooler. The desuperheated gas, together with



### . . . Centrifugal compressors for high displacement

the flash gas created by the expanding liquid, proceeds to the high stage Refrigerant-12 compressor (8). The high stage compressor elevates the pressure and temperature to its highest point where cooling tower water, circulating through the tube side of the condenser (9), removes the total heat of condensation of the Refrigerant-12. The condensed liquid drains by gravity to the high stage Refrigerant-12 intercooler (10) where it is expanded to some intermediate pressure by a float device. Flash gas liberated at this point is removed to the third impeller of the four provided in the high stage compressor. The remaining liquid in the high stage intercooler is expanded through another float device to the Refrigerant-12 interstage gas and liquid cooler (7) and additional flash gas, created by the lower pressure, is mixed with the discharge gas from the intermediate stage compressor (6) along with the evaporated liquid caused by the desuperheating effect. This gas is removed to the high stage compressor and the remaining liquid flows by gravity to the low stage Refrigerant-12 intercooler (11) from where additional flash gas is relieved to the third wheel of the intermediate stage compressor (6). The liquid is expanded through the final float device to the shell side of the cascade condenser from where it is circulated by Refrigerant-12 liquid pump (12), over the tube surface to complete the

To give a better understanding of the basic flow diagram, from the standpoint of applied thermodynamics, pressure-enthalpy flow diagrams are indicated in Fig. 2 and Fig. 3, for Refrigerant-13 and Refrigerant-12 respectively. A lettering system has been applied to Fig. 1, with the corresponding points located on Fig. 2 and Fig. 3. The temperature, pressure, and en-thalpy conditions shown are for the minimum temperature operating condition, -157°F refrigerant evaporator temperature.

The operation of Fig. 2 is tied to the operation of Fig. 3 in this respect -the condensing load at -96.5°F (plus a small amount of desuperheating load) on Fig. 2, must be taken care of by the evaporative cooling at -104.5°F on Fig. 3. The temperature difference, -96.5°F condensing Refrigerant-13 to -104.5°F evaporating Refrigerant-12, is required for heat flow across the condensing heat transfer surface in the refrigerant cooled-

refrigerant condenser (3), Fig. 1. One interesting aspect of the system which makes it differ, to some extent, from other two-refrigerant systems, is that involving the construc-tion of the Refrigerant-12 cooled Refrigerant-13 condenser. This heat exchanger is provided with a second circuit, in parallel with the Refriger-ant-13 condenser tubes, which is also cooled by the evaporation of Refrigerant-12. This second circuit is equipped for the circulation of brine, so that moderate temperature brine cooling can be accomplished at this point by the operation of the Refrigerant-12 system only, with the Refrigerant-13 system shut down. In other words, the Refrigerant-12 two stage system can operate either to remove the heat of condensation from the low temperature Refrigerant-13 system for the lowest temperature brine operation, or can alternately operate to cool brine directly.

Centrifugal compressors are necessary on this installation due to the high displacement required. The use of Refrigerant-13 in a centrifugal compressor is rather unique, this refrigerant generally not being in considerable usage since it is a low temperature refrigerant, and previous applications having involved considerably smaller plant sizes below the capacity of centrifugal compressors.

### A pressure problem

The use of Refrigerant-13 presents a problem in the matter of pressure build-up on plant shutdown. At ambient temperatures in the neighborhood of +80° F, which would prevail throughout the system after prolonged shutdown, the Refrigerant-13 portion of the circuit would be subjected to a pressure of about 500 psig and even higher, were any refrigerant permitted to remain in the liquid state. This pressure is prohibitively high for the economic design of refrigeration equipment. The alternatives are either to maintain the Refrigerant-13 liquid at all times at a temperature such that the pressure is held within reasonable bounds, or to provide an expansion tank.

The expansion tank used on this system was designed to provide sufficient standby volume so that as the temperature within the system rises, corresponding to a shutdown condition, all of the Refrigerant-13 liquid will be permitted to evaporate to a gaseous form. Sufficient volume is pro-

vided so that the increase in pressure, in conformance with Charles law for the refrigerant in the vapor state, will not result in excessive pressures. For the 5700 pound Refrigerant-13 charge required by the plant, an expansion tank was provided with a diameter of 10'-6" and a height of 33' corresponding to a volume of 2860 cubic feet. Consequently, the Refrigerant-13 vapor can warm up to 100°F without exceeding the 150 psig design working pressure of the tank. It is important that this condition be provided for, as pressures above the design working pressure of the expansion tank would result in refrigerant loss to the atmosphere via the relief valves and the dollar loss would be considerable. Due to the limited use of Refrigerant-13, the cost per pound is still rather high.

For the satisfactory operation of the plant, it is necessary to give consideration to the problem of purging both the Refrigerant-12 and the Refrigerant-13 systems. During conditions of low temperature operation, both systems will be operating in a vacuum on the evaporator side of each circuit. This means that any leakage at the suction of these compressors will be into the system, and it is therefore prudent and good design to provide a rather continuous and automatic purging system for the removal of air and foul gases. Purge systems, involving the use of small reciprocating compressors, condensers, and relief de-

vices are provided.

Table 1 shows design data on the operation of the refrigeration system for two specified tonnage conditions. Condition A corresponds to the 100 ton load at -137° F air temperature and condition B corresponds to 350 tons at -75° F air temperature. Each of the three centrifugal compressors consists of four impellers so that in pumping the heat from the evaporator up to the temperature level of the condenser water, a total of 12 centrifugal wheel stages is involved. It is interesting to note in Table 1 the increase in load as the heat is carried from the lower stage, successively up to the condensing conditions, showing the effect of the added BHP in each compressor.

Figure 5 shows the brine cooling capacity for the complete operating range of the system. For low temperature conditions, corresponding to a brine range from −150° F to about -93° F, all three stages would be in

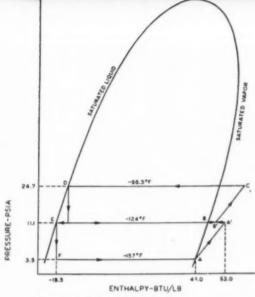


Figure 2. Refrigerant-13 system

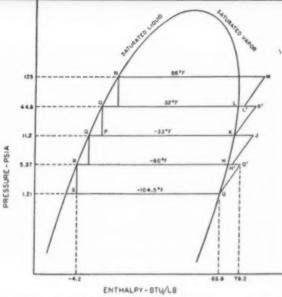


Figure 3. Refrigerant-12 system

operation. At brine temperatures from about -100° F to about -35° F, the low stage Refrigerant-13 system would be shut down, and the brine would be cooled in the brine flow circuit provided in the cascade condenser. At temperatures above this level, in the range from -20° F to +80° F, the low stage of the Refrigerant-12 system would be shut down and only the high stage compressor would be in operation. This provides an excellent range of flexibility for this plant. The corresponding operation of the compression system, showing tonnage capacity and BHP requirements of the compressors at different evaporator temperatures, is shown in Figure 6.

Automatically operated pre-rotation vanes are provided on the centrifugal compressors to obtain modulation of the capacity. For an even further reduction in capacity, beyond the limit of the vanes, hot gas recirculation control is provided on all three compressors. By this device, gas from the discharge side of the compressor is desuperheated and returned to the suction side in order to build up an artificial load if a real load does not exist in sufficient quantity to permit stable operation of the compressor.

Mention has been made of low temperature brine cooling, both in connection with the Refrigerant-13 cooled low temperature brine cooler and the higher temperature Refrigerant-12 cooler. The heat transfer liquid selected for this duty, with an operating range from  $-150^{\circ}$  F to  $+200^{\circ}$  F, is Refrigerant-11 (CCl<sub>3</sub>F), • (see footnote col. 3.) Low viscosity, even at -150° F, low vapor pressure (89 psig at 200° F) non-toxic and nonflammable characteristics resulted in its selection.

The use of brine in this system was most desirable from the standpoint of ease in handling and simplicity in design, in contrast to a direct expansion system with the circulation of refrigerant to the altitude chamber itself. In addition, a brine was necessary from the standpoint of storage capacity, and to provide a stabilizing influence for quickly varying chamber load conditions. Over a half million pounds of Refrigerant-11 is used in this installation to provide the storage capacity required. By cooling this mass of brine to -150° F, the chamber can be held down to low temperature over a weekend without the operation of the refrigeration compressors. Secondly, on a fast temperature pulldown, required to simulate quickly changing conditions, an instantaneous cooling capacity is obtained far in excess of the capacity of the refrigeration equipment. Thirdly, the presence of the brine system permits many advantages related to the ease of operation and flexibility of the plant.

TABLE 1 Refrigeration System Details

Condition	Α	В
Low Stage Compressor		
Evaporator Temp. °F.	-158	-115
Condensing Temp. °F.	-96.5	- 38
Tons Ref.	120	375
Comp. CFM (Actual)	3,525	3,225
BHP	204	676
Motor HP	900	900

ntermediate Stage Com	pressor	
Evaporator Temp. °F	-104.5	- 56
Interm. Temp. °F.	- 32	+ 36
Tons Ref.	162	517
Comp. CFM (Actual)	13,000	9,950
BHP	272	1,010
Motor HP	1,250	1,250

High Stage Compressor

Suction Temp. °F.	- 33	34
Cond. Temp. °F.	92.5	104.0
Tons. Ref.	219	731
Comp. CFM (Actual)	2,455	2,210
BHP	538	1,218
Motor HP	1,250	1,250

Stripped to its essential features for the purpose of illustration, the brine system is indicated diagrammatically in Figure 7. The brine storage is carried in two tanks, with the third serving as a spare and secondly, serving the dual function of accommodating the expansion and contraction of the brine throughout the system.

The two operating tanks are filled at all times during operation and the principle of stratification is applied to take advantage of varying brine storage temperatures. By the use of slender diameter, relatively long storage tanks arranged vertically, each 12' in diameter and 30' high, temperature stratification is available for a beneficial advantage. Warm brine is maintained at the top of the tank and cold brine at the bottom and a system of brine distribution for entrance and removal from the tank is such that a minimum of disturbance is created.

With the top and bottom valves to the storage tanks open, the brine circuit to either brine cooler is open to the storage tanks, and brine to the

\*While this fluid is normally used as a refrigerant, its use in this application is strictly as a brine as defined in the American Standards Association Safety Code for Mechanical Refrigeration ASA B9.1 -1953. "Brine is any liquid, used for the transmission of heat without a change in its state, having no flash point or a flash point above 150° F determined by American Society for testing Materials Method D93-52." cooler is from the warm brine at the top of the tanks and return brine from the cooler is into the bottom. The operation of the brine pump is therefore stabilized since there is no difference in static head to be overcome as would be the case if brine were pumped from one tank to another with varying temperature levels in The three-way mixing each tank. valve in the brine cooler circuit permits setting of a temperature either from the standpoint of protection to the refrigeration equipment or to maintain a fixed brine temperature supplied to the altitude chamber.

The chamber coil circuit involves an independent pump and an independent three-way mixing valve to provide control of the air temperature within the altitude chamber. The piping is so arranged that the brine storage tanks also serve as a reservoir for cooling, and in this case the brine to the chamber coils is taken from the bottom of the tanks corresponding to the coldest brine available. The warm return brine is then returned to the top of the tanks. The two separate paths of travel, the brine cooler and the chamber coil circuits, are brought together at the connections to the brine storage tanks. This automatically provides that the coldest brine, that from the brine cooler, will be available to the altitude chamber coils, with this brine supply receiving precedence over the storage brine. For example, if 1000 gallons per minute brine is available from the brine cooler in satisfying the set temperature requirements of the brine cooler mixing valve, then this brine would be available for circulation to the altitude chamber. If the chamber coils require 1400 GPM, the 1000 GPM from the brine cooler

would circulate to the chamber, and would circulate to the chamber, and the additional 400 GPM would automatically be drawn from the reservoir.

A study was made regarding the stratification ability in a tank of this

design, with the analysis involving conductivities of the tank metal and Refrigerant-11 brine and was based on the experience from similar installations operating at higher temperatures. The conclusion was that this arrangement would operate quite satisfactorily in the separation of warm fluid at the top and cold fluid at the bottom, as required for the optimum operation of the plant.

The brine is maintained under pressure, in order to prevent any flashing throughout the circuit, by a system of inert nitrogen, which maintains a pressure to a maximum of 150 psig. By permitting a pressure variation from about 90 psig to a maximum of 150 psig, the design working pressure of the tanks, a considerable variation in brine temperature can occur before any inert gas must be relieved from the vessel. As a matter of interest, Refrigerant-11 brine has a relatively high coefficient of expansion in the liquid state, and due to the high temperature variation from -150° F to +200° F, there is about a 25 percent variation in volume of the brine.

Due to the low temperature operation required, special materials of construction were used in many parts of the refrigeration and brine systems. For the low temperature brine cooler, 31/8 nickel steel was used for the shell, forged steel tube sheets, pressed steel brine heads and flanged connections. Charpy impact tests were made at -160° F on samples of the material and weld sections. The use of non-ferrous tubes eliminated the need

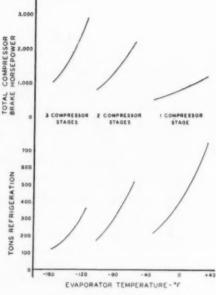


FIG. 6 - COMPRESSOR PERFORMANCE

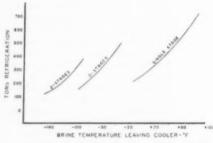


FIG. S-REFRIGERATION CAPACITY VS. BRINE TEMPERATURE

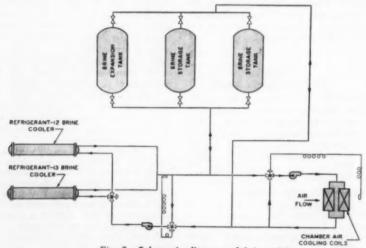
for impact tests. Stainless steel stud bolts and nuts were provided at the flange connections.

The Refrigerant-12 cooled Refrigerant-13 condenser required 3%% nickel steel construction in the areas exposed to Refrigerant-13 and Refrigerant-11 brine, including the tube sheets and fabricated heads. Again samples of material and weld sections from these parts were Charpy impact tested, here to -150° F. Non-ferrous tubes were also used in this shell.

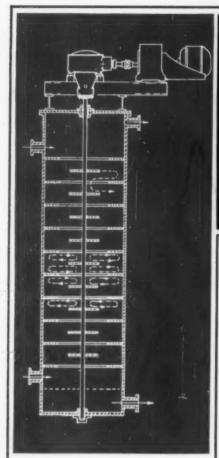
Cast iron was used for the centrifugal compressor casings. Brine tanks, piping, and fittings were constructed from 3%% nickel steel. Valve and pump casings contain 31% nickel iron, with stainless steel or non-ferrous parts.

In summarizing, this system is unique in its large refrigeration capacity at low temperature levels and its huge brine storage system for even greater cooling duties.

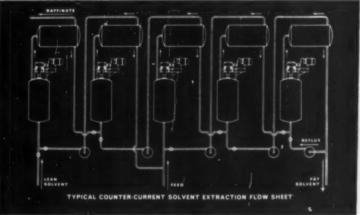
Each increase in load requirements at more extreme temperature levels creates new problems for the design and application engineers. This installation is felt to be a stepping stone in pioneering even larger systems.



Schematic diagram of brine piping.



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Turbo-Mixers are designed for maximum service, based on over 40 years of experience and specialization in mixer construction. For descriptive information showing how your problems may be solved by Turbo-Mixer, write today.

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RDC Extraction Column Bulletin\_\_\_\_

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# New plant spotlights tantalum-columbium

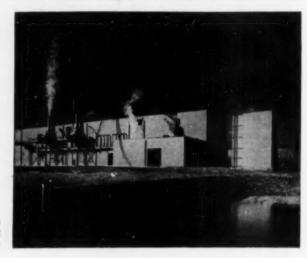
Twenty years ago, one ton of tantalum filled the world's needs for a year. Today, a ton is less than a week's supply.

Situated on 113 acres on the west bank of the Arkansas River near Muskogee, Okla., is a new tantalum-columbium plant. Built by Fansteel Metallurgical Corporation at a cost of \$6.5-million, the plant underlines the importance of the two metals. Entirely financed privately, the four-building plant was begun in 1956 when it became clear that demand for tantalum-columbium was outstripping production.

The new plant is designed and equipped to produce tantalum and columbium metal powders and ingots, and most of the present equipment can be used to produce either metal. Both metals occur in the same ores.

Best grades of tantalite (the ore with more tantalum than columbium) are found in Africa, South America, and Australia. Columbite (more columbium in the ore) deposits are found in Nigeria and several parts of North America.

The two metals cannot be produced by simple smelting. To obtain the required purity, a complex series of chemical and electrochemical opera-



Chemical Operations building of new plant.

tions are used. Rigid process control is a must, a technical staff in a control laboratory is required to supervise every step of the way. The actual processes used by Fansteel are the result of many years R&D by the company, are still under wraps.

The present set-up is semi-automatic, with much of the operation controlled from a central control panel.

Once the pure metals have been obtained in powder form, they are blended into batches of proper particle size distribution ready to be made into capacitor electrodes or ingots. If ingots are desired, the powder is compacted under pressure into bars. The bars are placed in special vacuum sintering furnaces where heavy electric current is passed through them. The bar acts

as its own heating element, and the powder particles fuse together without actually melting the entire bar.

Process equipment and capacitors

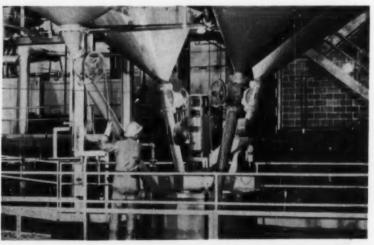
Ingots of both metals are processed into sheet, foil, rod, wire, tubing and a large variety of fabricated products.

One of the more promising uses for tantalum is acidproof equipment for the chemical industry. Such things as heat exchangers, condensers, and acid recovery equipment have already been made from tantalum with considerable success.

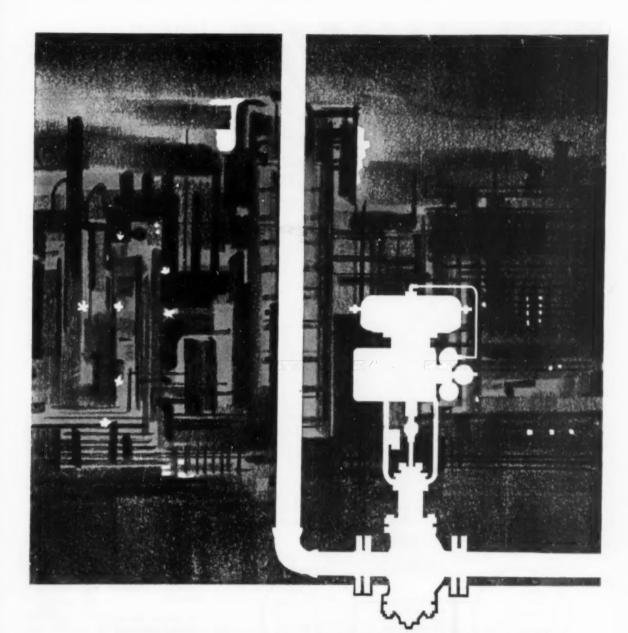
The major demand for tantalum at present is in the tantalum capacitor, a Fansteel development. The tantalum continued on page 90



Making ingots from compacted



Purification and separation of tantalum-columbium salts requires precise process control in many chemical operations at Muskogee.



### ...almost forgotten...because it does its job so well!

Dependable, year-after-year performance makes a Fisher Diaphragm Motor Valve the preferred control in the power and process industries. The Fisher D.M.V. has features not available on other brands. The extra thick steel casing, the precision finished valve stem, the large capacity and the trouble-free operation—these are just a few of the reasons a Fisher gets the nod when it comes to diaphragm motor valve selection.

If you want to know more about the ultimate in control—the Fisher Diaphragm Motor Valve—write for Bulletin E657A.



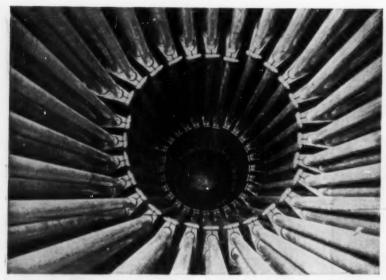
F IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY

### FISHER GOVERNOR COMPANY

Marshalltown, lowa / Woodstock, Ontario / London, England



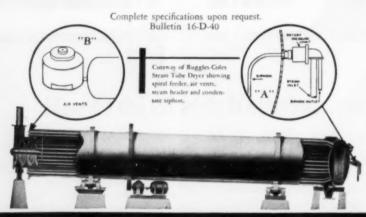
SINCE 188



# Ruggles-Coles STEAM

TUBE DRYERS

- Ruggles-Coles Steam Tube Dryers have been supplied fabricated of aluminum, nickel, monel, inconel, stainless steels and other alloys to provide protection against corrosion and contamination. All fabrication is to code requirements,
- The continuous siphon discharge of condensate is independent of speed of rotation of the shell. (See "A")
- Automatic air vent for each tube eliminates loss of tube heating surface at the feed end of the dryer. (See "B")
- These extra advantages of the Ruggles-Coles Dryer mean continuous maximum output without operating attention and elaborate control devices.



# HARDINGE COMPANY, INCORPORATED

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### tantalum

from page 88

capacitor has become an important component in many types of electronic circuits, where it is said to provide higher reliability and greater capacitance in smaller space than any other type of capacitor.

Columbium is being used in some types of nuclear reactors, and experimental work is underway on columbium alloys for resistance to corrosion and high temperature, with a particular eye on the constant needs of the chemical industry for equipment with these advantages.

With the opening of the Muskogee plant, the shortage of tantalum and columbium has already eased. The goal of Fansteel is to have all parts made from these metals, as well as the metal ingots and powders, available from stock at any time. The Muskogee installation will increase the productive capacity for tantalum by 50% and for columbium by 150%.

Commercial production of lithium perchlorate is underway at Lithium Corp. of America. Up until now, the company has produced only research quantities. An important oxidizing agent, the compound contains more available oxygen than liquid oxygen itself. It is a stable, easily handled solid containing 91 pounds of oxygen per cubic foot of volume.

The fifth major expansion of Foster D. Snell in recent years is the recent acquisition of Davis & Bennett, Inc. of Worcester, Mass. Davis & Bennett is a 35-year-old firm of consulting chemists, chemical engineers, and biologists.

An unique arrangement which will enable Continental Oil Co. to employ a gas turbine at its Lake Charles refinery, and to reclaim and use the large amount of heat in the exhaust gases which would otherwise be wasted, has been designed into a new boiler built for Continental by Babcock & Wilcox. To accommodate these gases the boiler will have a slightly larger than standard furnace envelope or volume. Since this construction requires more radiant boiler surface, the boiler's forced draft fan capacity will be increased, and one additional burner will be added, providing an hourly output of 180,000 pounds of steam from conventional operation. When the hot exhaust gases are used, the rating will be 150,000 pounds an hour.



Girdler can help you find and apply licensed processes for improved chemical production

To enable you to improve your competitive position in "tonnage" chemicals, Girdler offers this three-part engineer-constructor service:

We know where to go to secure licensed processes which may offer advantages to you in production economy or quality.

We know how to translate the process and plant design into U. S. standards and code requirements.

We know how to apply the process to your needs and to build and equip the plant.

May we discuss this with you in further detail?





When it is a question of handling corrosive fluids in processing or hydraulic equipment

-Chemlon Connectors best meet the need. They are fabricated from the most chemically resistant material available, DuPont Teflon. The most destructive acids, corrosives and solvents have no deteriorating affect\*

Other important advantages are their long service-life, extreme flexing ability and wide temperature range from -65°F. to +350°F.

Chemlon flexible pipe connectors offer a definite plus value construction-wise. 1) They are made from Teflon specially fabricated for high and uniform density. 2) An exclusive manufacturing method assures uniform wall thickness throughout the convoluted area. 3) They are formed at full free length to reduce residual and working strain to an absolute minimum.

### Vibration and Misalignment



-severest vibration and misalignment conditions, such as pump to agitator or mixer to tank, will cause little deterioration or fatigue. Also, the Chemlon Flexible Pipe Connector serves as an acoustical

as well as a mechanical dampener.

### **Expansion and Contraction**

+VVV+

-continuous flexing over a wide range of temperature conditions has little affect on Chemlon Flexible →WM← Pipe Connectors.

### CUSTOM FABRICATED

Chemlon Flexible Pipe Connectors can be custom machined or molded to meet any requirement from one convolution up...any shape or size . . . open or closed end. They handle pressures to 75 psi.

Request full information. Crane Packing Co., 6443 Oakton St., Morton Grove, Ill., (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

\*Except fluorine and molten alkali metals













### Boost For Vinyl Chloride

New plant for Ethyl Corp., doubled capacity for Solvay Process Division (Allied). brings large new production of vinyl chloride monomer to the market.

THE NEW PLANT at Baton Rouge, La., is Ethyl's first step in the vinyl chloride field. Ethyl is being coy about production figures but industry-wide guessing indicates that a figure of 60 million pounds a year would not be too far off. This would boost total U.S. capacity to over 850 million pounds

Ethyl's vinvl chloride monomer will be produced by cracking ethylene dichloride made by the reaction of ethylene and chlorine. The resulting byproduct hydrogen chloride will be utilized in other intermediate chemical manufacturing operations at the plant. (Ethyl is a major producer of ethyl chloride, ethylene dichloride, and other such chemicals.)

Contractor for the engineering and construction of the new plant was Catalytic Construction, Philadelphia. The plant is said to be the first in Louisiana to produce the monomer commercially.

The expansion of Solvay Process Division's Moundsville, W. Va., monomer plant will double present capacity. The Moundsville installation continued on page 94



Ethyl's new vinyl chloride monomer plant at Baton Rouge, La., new field for Ethyl.

# SPECIFICATIONS

FLOW MEDIUM

RATE OF FLOW

OPERATING TEMPERATURE

OPERATING PRESSURE

DIFFERENTIAL PRESSURE

MAXIMUM PARTICLE PASSED TO MICRONS

MAXIMUM PARTICLE PASSED TO MICRONS

SELF CLEANING BY BACKFLOWING AND/OR

VIBRATING AT FREQUENCY OF 100 CYCLES PER SEC.

WITH FORCE OF 5 "G-s"

# Do you have filtration problems as tough as this?

### PUROLATOR'S ENGINEERING SALES STAFF WILL HELP YOU SOLVE THEM

The requirements above are not hypothetical . . . they are typical of specifications to which Purolator has designed and built filters. The filtering elements designed for this application combine two forms of a porous metal media to obtain the required filtration qualities with the structural strength needed to withstand the punishment of the self-cleaning action — plus the temperature gradients and the effects of corrosive materials.

Purolator's engineering staff specializes in designing and building filters for difficult applications like this. The emphasis is on engineering, by a staff of "Q" and "L" cleared filtration experts, backed up by complete manufacturing facilities, able to produce filters or separators of any known media to operate within these wide ranges of conditions: TEMPERATURES: from -420° to 1200° F.

PRESSURES: from a nearly perfect vacuum to 6,000 p.s.i.

RATES OF FLOW: from drop by drop to thousands of GPM.

**DEGREES OF FILTRATION:** from submicronic to 700 microns (in various media).

This complete filtration service, for the toughest problems in nuclear and chemical applications, is available only at Purolator. Purolator's engineers are ready to work on your requirements. If you have an *urgent* need for specially designed filtration systems, call Jules Kovacs, Vice President in charge of Research and Development and Product Application . . . or send him the details of your application.

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That's why Elliott Twin Strainers are so widely used by power plants and industry. They protect expensive liquid-handling equipment by straining liquids—without interrupting the flow. Shifting the flow from one strainer basket to another is accomplished easily by turning two valve wheels. Removing and dumping the strainer basket is simple. The result:

the chance of objectionable solids gumming-up the works is eliminated.

The Elliott line of strainers also includes Single, and Self-Cleaning Strainers in sizes ranging from 1" to 24", and with straining perforations from 3%" down to fine wire mesh. For further details contact your local Elliott District Office or write Elliott Company, Jeannette, Pa.

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# ELLIOTT Company 1

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### For Vinyl Chloride

from page 92

uses a process developed entirely within the Allied Chemical organization, and involving the use of anhydrous hydrogen chloride and acetylene, both of which are available in the immediate vicinity of the expanded plant. The HCl comes from Solvay's own chloromethanes operation, the acetylene from an adjacent producing plant.

Diamond Alkali is a third factor in the picture with a plant in the construction stages at Deer Park, Tex. This will add some 50 million pounds more to the total vinyl chloride monomer production of the country. Diamond had planned to be on-stream just about now, but the completion date has been set back to somewhere near "midvear".

Behind all the activity in the monomer is the continuing growth of polyvinyl chloride (PVC). In 1957, PVC production had climbed to an estimated figure of 645 million pounds. The industry feels fairly confident in predicting that by 1961 the vinyl chloride resins will reach one billion pounds a year. With this target for PVC, the expansions in the monomer are not surprising, more will probably come, Ethyl's entry into the field seems a safe investment in a solid market.

Allied Chemical and Dye Corporation will be renamed Allied Chemical Corporation. The new name is intended to simplify identification of the major chemical producer, to remove any over-emphasis on any single division of the company, and, as a practical matter, to use the name the company has come to be known by most frequently in recent years.

A licensing agreement has been made between U.S. Polymeric Chemicals, Inc., Stamford, Conn., and American Reinforced Plastics of Los Angeles. The agreement covers prepregs prepared from resins in the Hi-Heat field.

A multi-million dollar Dacron polyester fiber plant will be built by Du Pont at Old Hickory, Tenn. Design will be for an ultimate production of 56 million pounds of the staple fiber and filament. Initial staple production is slated for mid-1959.

Facilities for the manufacture of vinyl stabilizers and plasticizers are being expanded at Argus Chemical Corp.'s Brooklyn, N.Y., plant. #

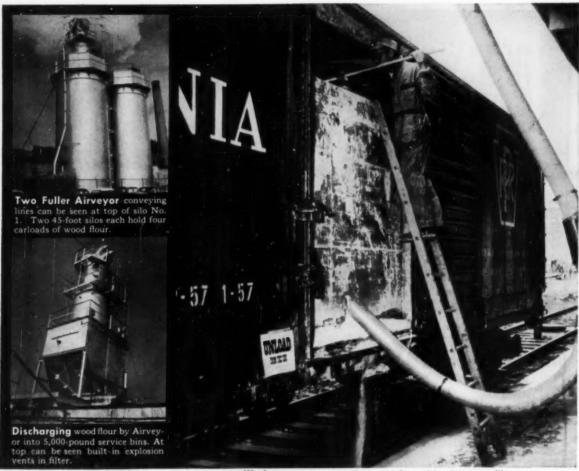
Versatile ... Flexible... Adaptable STRATCO CONTACTORS

- \*A dominant factor in alkylation through production of better alkylate with less catalyst consumption and other economies.
- \* Widely used in grease making to produce a more uniform soap with shorter time cycles and reduced manpower requirements.
- \* A leader in new fields of continuous sulfonation, lube oil treating and for other contacting purposes.
- \* The answer to many "unsolvable" petrochemical and chemical problems requiring close temperature control in the reactor.

Stratco Contactors may be designed for almost any degree of mixing short of homogenization. With internal heat transfer surface they provide extremely close control of temperature throughout the entire liquid volume of the contactor. The reacting liquids are maintained in the desired degree of dispersion throughout their residence time, and residence time may be varied to suit the problem. Stratco Contactors are available in sizes from 300 cc volume laboratory units up to 11000 gallon volume or larger commercial sizes.

• They are adaptable to your process problems ... large or small

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D. D. Foster Co., Pittsburgh Rawson & Co., Houston and Baton Rouge
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Workman starts unloading wood flour with minimum spillage as it is withdrawn from the box car by Fuller Airveyor.

### GENERAL ELECTRIC SWITCHES FROM BAG-CARRYING TO ATRVEYOR, CUTS HANDLING COSTS 60%

As part of a program to increase plastics production and reduce operating costs at its Pittsfield, Mass. plant, General Electric Company recently called in Fuller Engineers to design systems for handling wood flour in bulk.

Wood flour-used as a filler in phenolic molding compoundswas being handled in 75 and 100-pound bags. Unloading one carload of bags required 16 manhours. Bags were loaded on dollies and wheeled to a distant elevator.

### SAFETY FIRST

The two pneumatic Airveyor® materials handling systems, engineered and manufactured by Fuller Company, were installed by its parent company, General American Transportation Corp., providing undivided responsibility. This installation resulted in a 60% saving in handling cost! The two systems are handled by one full-time and one part-time operator. Manhours to unload one car have been reduced from sixteen to six!

In addition, all equipment is designed to conform to strict safety specifications set down by G-E engineers.

### FLOW YOUR WOOD FLOUR

The Airveyor is a system that flows your wood flour through sealed pipes. It's fast, safe and self contained. The pipes can be placed close to ceilings, run underground or through walls.

Whether you process wood flour-or other dry granular materials-look into the many economies of Airveyor conveying. Write today for interesting, detailed literature on Airveyor and other Fuller pneumatic materials handling systems.

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### **FULLER COMPANY** 174 Bridge St., Catasauqua, Pa.

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### Floating Plastic Blankets Cut Evaporation Losses

(For further data, circle Number 395 on Data Post Card)



More than 125 installations in Europe have demonstrated that floating plastic blankets in storage tanks can cut evaporation losses of gasoline and other volatile materials by 90% or more. In smaller sizes (the 12-foot standard diameter, for example), the blankets can be rolled up like cigars and installed in minutes through the roof manholes of tanks in service: larger sizes are custom built in sections to fit tanks up to 100 feet in diameter.

The bottom of the blanket is in the form of a continuous flexible carpet, the underside of which is provided with a large number of small floats. A vertical raised float on the edge of the blanket serves to maintain a vapor seal which is saturated by the evaporation of the stored liquid over the free annular surface of the liquid. This seal stops evaporation almost completely: the only possible loss is that resulting from gaseous diffusion, which is extremely slow.

re ree annuar surrace of the liquid. This seal stops evaporation almost completely: the only possible loss is that resulting from gaseous diffusion, which is extremely slow.

The blanket is provided with openings fitted with vertical sleeves, to enable measuring and sampling operations to be carried out, and to allow the float of the level indicator to pass through.

Increased safety is one of the features claimed for the new technique. The completely incombustible floating blanket almost completely isolates the surface of the liquid from the vapor phase. Since it possesses considerable resistivity, it does not transmit the electrostatic charges which may be present in the liquid underneath. Thanks to the vertical skirt, the annular gap on the edge of the blanket is always in contact with a ring of air saturated with vapor; this makes any explosion practically impossible. In addition, in tanks of over 17 feet in diameter, the floating blanket is fitted with an antistatic screen to trap and lead away any electrostatic charges which may rise to the surface during numping or which may accumulate in the liquid.

tanks of over 17 teet in diameter, the notting blanker is fitted with an antistatic screen to trap and lead away any electrostatic charges which may rise to the surface during pumping or which may accumulate in the liquid.

The plastic blankets are made by Leroche Bouvier of France: American representatives are Devys & Lobo of New York. Complete technical details are available in a bulletin and other descriptive literature. Circle Number 395 on the Data Post Card.

### **New High Temperature Synthetic Rubber**

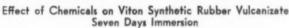
(For further data, circle Number 396 on Data Post Card)

Viton, a new elastomer, developed by Du Pont and scheduled for commercial production by early April, is said to possess unequalled resistence to cils, fuels, and solvents at temperatures above 400°F. The new material is a linear copolymer of viny-lidene fluoride and hexafluoropropylene containing about 65% fluorine by weight.

While first applications of the new elastomer will probably be in seels for military aircraft and missiles, its outstanding resistance to heat, fluids, and compression set will undoubtedly lead to many applications in the chemical equipment field. The accompanying table shows changes in physical properties after seven days immersion

in common solvents, acids, and bases.

The present high price of Viton (\$15 a pound) is expected to make it suitable for small parts such as gaskets and seals, where its resistance to heat and chemicals can make it more economical than conventional materials. For further technical information, circle Number 396 on Data Post Card.





SOLVENTS	% Tensile Strength Retained	% Elonga- tion Retained	Points Hardness Change	% Volume Increase
Carbon tetrachloride, 75° F	85	83	+ 2	1.3
Ethyl alcohol, 75° F		100	+ 2	1.7
Aniline, 75° F	100	100	- 1	3
Tricresyl phosphate, 300° F	93	100	-11	24
Acetone, 75° F			-11	271
Methyl ethyl ketone, 75° F			-11	287
ACIDS & BASES				
Sodium hydroxide, 46.5%, 75° F	75	100	+1	2.1
Water, 212° F		100	+ 3	2.7
Sulfuric acid, furning, 75° F	58	69	- 4	4.8
Hydrofluoric acid, 48%, 75° F	98	100	+ 2	4.8

### **DEVELOPMENTS OF THE MONTH**





397 Reference Books on Bromine Michigan Chemical Corp. offers two new books, Bromine—Its Properties and Uses, and How to Handle Bromine. In its 64 pages, the compilation Bromine—Its Properties and Uses contains references to over 500 compounds. Main divisions of the treatise are: Inorganic Bromine Reactions; Organic Bromine Reactions; Special-Purpose Bromine-Releasing Agents; and Physical Properties of Bromine. A bibliographical section contains over 500 annotations.

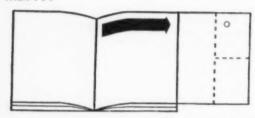
The second booklet, How to Handle Bromine, is a 36-page review on bromine's characteristics, containers and methods of shipment, bromine handling systems in plant and laboratory, accident prevention, and first aid.

For copies of these books, circle Number 397 on the Data

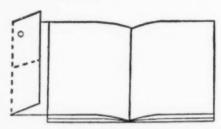
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AS YOU PASS the pull-out page, and it is on the left, fold the post card back along the vertical scoring, and once again the numbers are handy for circling.



Numbers followed by letters are for checking your interest in the products, equipment, and services advertised in this issue, the number corresponding to the page on which the ad appears. Letters indicate position on the page: L, left; R, right; T, top; B, bottom. A indicates a full page; IFC, IBC, and OBC are cover advertisements. Numbers in the 300-series bring you new engineering data in the chemical engineering field.

Be sure to include your name, address, and position.

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### Filter ware, sintered Furnaces, industrial .... 139A Gear reducers, shaftmounted . . . . . . 150L Grinders . . . . . 156R, 159A Heat exchangers ......14L plate-type . . . . . . . . . . 128L spiral .....128L Kettles . . . . . . . . . . . 1698L Kilns .....1FC Liquid Processing equip-Materials handling equipment. Meters, tank contents ...1728L Mixers ...9A, 11A, 159A, OBC Packers, mechanical .....3R Pipe connectors, flexible, Pumps ..........135A, 163A centrifugal, corrosion-

EQUIPMENT

Air conditioning equip-

ment ......148BL 

Coils, heating ...... 173TR
Collectors, dust ...... 27A
Compressors, air ...... 13A
Condensers, barometric,

ejector-jet ........158R

vapor, air-cooled ... 138BL Contactors ......95A

Freon ......101A

Conveyor-Elevators ..... 147A Coolers ......IFC

Corrosion Detectors . . . . 140L

Couplings, quick ......18A 

Decerators ......119A Deionizers, mixed-bed ... 146R

Dryers .....1FC, 133A, 149A drum ......117A steam-tube ......90L Electrodes, carbon ....103A

Feeders, vibratory .....118L

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Screeners, whirlpool- type169R
Scrubbers, fume, jet-
venturi137A
Separators, centrifugal 141A
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Sight glasses, Pyrex168BL
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MATERIALS           Catalysts, hydrogenation         110A           Diatomaceous materials         157A           Ethylene axide         15A           Filter paper         116L           Glucosates         166L           Linings, Kel-F laminates         111R
MATERIALS           Catalysts, hydrogenation         110A           Diatomaceous materials         157A           Ethylene oxide         1.5A           Filter paper         116L           Glucosates         166L           Linings, Kel-F laminates         111R           Packing, Teffon         173BR
MATERIALS           Catalysts, hydrogenation         110A           Diarlomaceous materials         157A           Ethylene oxide         15A           Filter paper         116L           Glucosates         166L           Linings, Kel-F laminates         111R           Packing, Teffon         173BR           tower         40A
MATERIALS  Catalysts, hydrogenation
MATERIALS           Catalysts, hydrogenation         110A           Diatomaceous materials         157A           Ethylene axide         15A           Filter paper         116L           Glucasates         166L           Linings, Kel-Flaminates         111R           Packing, Teffon         173BR           tower         40A           Steel, stainless         112A-113A           Sulfur         155A
MATERIALS           Catalysts, hydrogenation         110A           Diatomaceous materials         157A           Ethylene oxide         15A           Filter paper         116L           Glucasates         166L           Linings, Kel-Flaminates         11R           Packing, Tefton         173BR           tower         40A           Steel, stainless         112A-113A           Sulfur         155A           Wire cloth         136L
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computers ......167A

Process stimulation with

PRODUCT INDEX

Refrigeration equipment

### THE BENEFITS OF MEMBERSHIP

in the American Institute of Chemical Engineers are spelled out in the brochure "Know Your Institute," which also outlines the objectives of this nation-wide organization of chemical engineers and includes a membership blank for your convenience. Circle num-ber 367 on Data Post Card.

resistant ...........138TL controlled-volume ......7A

jacketed ........168BR gear, Teffon .....108L glass-lined ....130A-131A

graphite ......129A

leakproof ......125A

gear, steam-

- IFC Dryers, Coolers, Calciners, Kilns, Bull. 118 from C. O. Bartlett & Snow.
- 3R Mechanical Packers, Bull. 401 from B. F. Gump on Vibrox packers.
- 4A Entrainment Separators. Bull. 20 from Otto H. York Co.
- 6A Special Expansion Joints. Adsco Div., Yube Consolidated Industries.
- 7A Controlled-Volume Chemical Pumps. Bull, 440 from Lapp Insulator Co.
- 9A Mixing Equipment. Bull. from Simpson-Mix-Muller Div., National Engineering Co. 10L Plastic Pipe. American Hard Rubber Co.
- IIA Mixers. Catalog A27 from Philadelphia Gear Works
- 13A Industrial Air Compressor Bulletin. Cooper Bessemer.
- 14L Heat Exchangers. Aerofin Corp.
- 15A Ethylene Oxide. Booklets from Union Carbide Chemicals.
- 16L Automatic Weighing Equipment. Thaver Scale Corp.
- 17A Pan-Type Filters, Eimco Corp.
- 18A Quick Couplings. Ever-Tite Coupling
- 23A-24A New Technical Developments. Bulis. from U. S. Industrial Chemicals.
- 25A Steam Trap Bulletin. Armstrong Machine Works.
- 26B Welded Chemical Vessels. Bull. from R. D. Cole Mfg. Co.
- 27A Dust Collectors. Bull. 52A from Pulverizing Machinery Div., Metals Disinte-grating Co.
- 28L Steam Vacuum Refrigeration Equipment. Bull, 60-A from Graham Mfg. Co.
- 29A Evaporators. Chicago Bridge & Iron
- 30L High Alloy Castings, Bull, 3354G from Duraloy Co.
- 31A Liquid Processing Equipment. Catalog 117 from Rodney Hunt Machine Co.
- 32A Glassed Steel Tank Trucks. Data Sheet 29 from Pfaudler Co.
- 33A Non-Lubricated Lift-Plug Valves. Cameron Iron Works.
- 35A Process Equipment Fabrication, M. W. Kellogg Co.
- 36A Process Equipment Fabrication. Downingtown Iron Works.
- 38A Cold-Extruded Prefabrication. Bull. CE-0.001 from Fluor Products Co.
- 40A Tower Packings, Bulls, S-29, TP-54, and TA-30 from U. S. Stoneware.
- 87A Solvent Extraction Equipment. Turbo-Mixer Div., General American Transportation.
- 89A Diaphragm Motor Valves. Bull. E657A from Fisher Governor Co.
- 90L Steam Tube Dryers. Bull. 16-D-40 from Hardinge Co.
- 91A Plant Design and Construction. Girdler
- 92L Flexible Teffon Pipe Connectors. Crane Packing Co.
- 93A Filters. Purolator Products, Inc.
- 94L Twin-Type Strainers. Elliott Co.

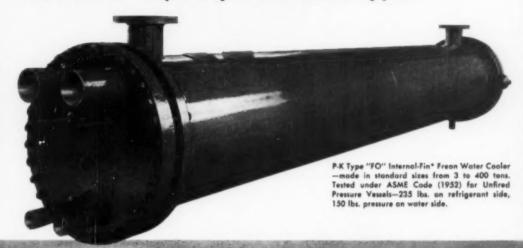
- 95A Contectors. Stratford Engineering Corp.
- 96A Pneumatic Materials Handling Equipment, Fuller Co.
- 101A Internal-Fin Freon Water Coolers. Bull. 106-T-1 from Patterson-Kelley.
- 103A Carbon Electrodes. Great Lakes Carbon Corp., Electrode Div.
- 105A Air Preheaters, Air Preheater Corp. 107A Plant Design and Construction. Lummus Co.
- 108L Teflon Gear Pumps. Eco Engineering.
- 109A Steel Fabrication. Wickwire Spencer Steel Div. Colorado Fuel and Iron Corp.
- 110A Hydrogenation Catalysts. Girdler, Chemical Products Division.
- IIIR Kel-F Laminate Linings. Bull. AD-152 from United States Gasket.
- 112A-113A Stainless Steel. G. O. Carlson, Inc.
- 114L Impervious Graphite Equipment Estimating Data from Falls Industries.
- 115A Flow Control Equipment. Foxboro Co.
- 116L Filter Paper Catalog. Eston-Dikeman
- 117A Drum Dryers. Catalogs 380 and 381 from Buflovek Equipment Div., Blaw-Knox.
- 118L Vibratory Feeders. Catalog from Syntron Co.
- 119A Decerators. Bull. 2888853 from Allis-Chalmers.
- 120L Teflon-Lined Piping and Fittings. John L. Dore Co.
- 121A Process Equipment Fabrication. Graver Tank & Mfg. Co.
- 122L Stopcocks. Wilmed Glass Co.
- 123A Crystallizers. Bull. CE-57 from Struthers Wells.
- 125A Leakproof Pumps. Details from Chempump Corp.
- 127A Small-Diameter Tubing. Superior Tube.
- 128L Spiral and Plate Type Heat Exchangers. American Heat Reclaiming Corp. 129A Impervious Graphite Pumps. Notional Carbon Co.
- 130A-131A Glass-Lined Pumps. Bull. 725.2 from Goulds Pumps.
- 133A Closed Circuit Drying System. Details from Wyssmont Co.
- 135A Process Pumps. Aldrich Pump Co. 136L Industrial Wire Cloth Catalog. Cambridge Wire Cloth Co.
- 136BR Heatless Desiccent Air Dryers. Kahn and Co.
- 137A Jet-Venturi Fume Scrubbers. Catalog from Croll-Reynolds Co.
- 138TL Corrosion Resistant Centrifugal Pumps. Catalog from Bart Mfg. Corp.
- 138BL Air-Cooled Vapor Condenser. Bull. 129R from Niagara Blower Co.
- 139A Industrial Furnaces. Petro-Chem Development Co.
- 140L Corrosion Detectors, Data sheets from Tinker and Rasor.

- 140R pH and Chlorine Control Handbook. W. A. Taylor & Co.
- 141A Centrifugal Separators. Dorr-Oliver,
- 143A Oxygen and Nitrogen Plants. Air
- 145A Chemical Relief Valves. Details from Milton Roy Co.
- 146L Sintered Glass Filter Ware. Ace Glass, Inc.
- 146R Mixed-Bed Deionizer. Bull. 512 from Elgin Softener Corp.
- 147A Conveyor-Elevator. Catalog 556 from Stephens-Adamson Mfg. Co.
- 148TL Thermocouple Assemblies, Catalog Section E-V from Thermo Electric Co.
- 148BL Air Conditioning Equipment. Bulls. 112 and 131 from Niagara Blower Co.
- 149A Industrial Dryers. C. G. Sargent's Sons Corp.
- ISOL Shaft-Mounted Gear Reducer. Cafelog R-58 from Lovejoy Flexible Coupling
- 150BR Liquid Oxygen & Nitrogen Storage and Transportation Units. Catalog from Hofmann Laboratories, Inc.
- 151A Carbon Monoxide Plants. American Air Liquide.
- 155A Sulfur. Texas Gulf Sulphur Co.
- 156L Plastic Pipe Bulletin, Kraloy Plastic Pipe Co.
- 156R Crushing and Grinding Equipment. Bulls, from Sturtevent Mill Co.
- 157A Dietomaceous Materials. Dicalite Dept., Great Lakes Carbon Corp.
- 158L Nickel Alloy Equipment Fabrication. Misco Fabricators, Inc.
- 158R Ejector-Jet Berometric Condensers. Bull. 9012-A from Ingersoll-Rand.
- 159A Grinding and Mixing Equipment. Sprout, Waldron & Co.
- 163A Pumps. Fairbanks-Morse.
- 1648 Pressure Vessels. Posey Iron Works. 165A Process Equipment Fabrication. Yuba Consolidated Industries, Inc.
- 166L Glucosates, D. W. Haering & Co.
- 167A Process Simulation With Computers. Electronic Associates, Inc.
- 168BL Pyrex Sight Glasses. Bull. from Swift Glass Div. Swift Lubricator Co.
- 168BR Steam Jacketed Gear Pumps. Bull. 17-A from Schutte and Koerting Co.
- 169TL All Plastic Gate Valves. Catalog FP-1 from Vanton Pump and Equipment Corp.
- 169BL Kettles and Tanks. Catalog from B. H. Hubbert & Son, Inc.
- 169R Whirlpool Screener. J. M. Lehmann
- 172BL Tank Contents Meter. Bulls, from Uehling Instrument Co.
- 173TR Heating Coils. Bulls. from Dean Products, Inc.
- 173BR Teflon Packings. Brochure from Flexrock Co. IBC Plant Design and Construction. Ralph
- M. Parsons Co.
- OBC Mixing Data. Mixing Equipment Co.



# P-K Internal-Fin\* Chiller

gives you up to 40% reduction in size over same capacity bare tube type



\*Patent Pending

Where space counts—either in packaged units or on-site assemblies—you can design your installation for a shell 2 diameters less and 1 to 2 feet shorter than a conventional plain or bare tube cooler—if you use a P-K Type FO Internal-Fin Freon 22 Water Cooler.

In addition to space saving, you get the added benefits of reduced freon charge, reduced weight and lower cost. *Plus delivery in 4 to 5 weeks* on sizes from 3 to 400 tons—larger sizes available on special order.

When you consider the advantages of internal-fin coolers, remember that P-K gives you more internal surface area per linear foot of tubing than any other cooler of this type—remember that you gain faster heat transfer, enhanced vaporization of refrigerant—all through P-K advanced design and exclusive patent pending features of construction. Send now for Bulletin 106-T-1. Use the handy coupon to get detailed information. Or, write Patterson-Kelley Co., Inc., 1704 Burson Street, East Stroudsburg, Pa.



Refrigeration and Air Conditioning Division

Heat Exchangers • Converters • Condensers • Chillers • and All Types of Heat Transfer Equipment



Cross-section through tube showing internal-fin design. Serrated surface enhances refrigerant vaporization; large foot bonds to shell for faster heat transfer.



P-K Internal-Fin Coolers can be furnished insulated with Rock Cork leid in asphalt and covered with a heavy steel jacket. Illustration shows insulated cooler.

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Send me Bulleti Freon Water Co	n 106-T-1 on Type FO Internal-Fir colers
Name	Title
Company	
Address	
Citu	Zone State

### MATERIALS

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301 Catalog on Reinforced Polyester Molding Compounds. Atlas Power Co. offers 40-page catalog featuring data sheets on each of seven compounds. Selector chart facilitates selection of proper compound for given end use conditions.

302 Data Card on Alloy Steel Tubing Dimensional tolerances, both cold-drawn and hot-finished, of round, seamless carbon and alloy steel mechanical tubing in various conditions of heat treatment. Babcock & Wilcox Co.

303 Tributyl Aconitate. Technical grade of tributyl aconitate, a stable liquid plasticizer for vinyls, cellulosics, and styrene copolymers is now available from Ches. Pfizer & Co. Samples and further technical information from the manufacturer.

304 Data Sheet on Dysprosium Oxide. Physical, chemical, and high-temperature properties, also graph showing rate of moisture absorption under controlled conditions. Research Chemicals.

305 Sodium Chlorate Bulletin. "Sodium Chlorate—Properties and Safe Handling Practices" offered by Pennsalt Chemicals Corp. Many tables and charts.

306 Filter Aid. Folder from Sil Flo Corp. cutlines physical properties of their line of filter aids.

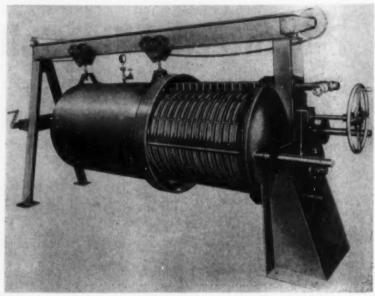
307 Polysulfide Liquid Polymer Applications. Report of current laboratory studies including use of aluminum and carbonatetype fillers. Bulletin from Thiokol Chemical Corp.

308 Anti-Corrosion Coating Data. Technical bulletin from Tube Reducing Corp. describes "Niphos" coating process, said to give any mild steel a resistance approaching that of stainless. Data on comparative costs and tables of corrosion in various media.

309 Basic Handbook on Aluminum Chemicals. 48-page book from Reynolds Metals Co. summarizes technology of present applications and suggests new uses for wide variety of aluminum chemicals. Many tables and charts on technical data.

310 Vapor Degressing with Perchlorethylene. Comprehensive date on use of vapor degressing in production cleaning and metal surface preparation for electroplating, painting, and other finishing operations. Includes discussion of degressing equipment, methods of scheduling cleancuts and operating procedures. Bulletin from Diamond Alkeli Co.

311 Silicon Carbide Ceramics. Technical bulletin on stabilized Crystolon ceramics from Norton Co. gives data on three new engineering materials: Crystolon "N" (nitride-bonded). Crystolon "R" (recrystallized or self-bonded), and Crystolon "C", a coating. The three ceramics offer high resistance to thermal shock and to temperature as high as 4,000°F.



398 New Vertical Leaf Pressure Filter.

A new design by T. Shriver & Co. employs vertical filter leaves in a horizontal cylindrical tank. The design is said to eliminate any limitation on the kind of filter medium that may be used, and to do away with any difficulty in cleaning, if the filter becomes overloaded and filter cake bridges across the leaves.

The filter may be used in two ways:

1. With filter leaves, open frames, and any textile or paper filter medium in sheet form to make up the filter chambers. For cleaning, the cake may be sluiced off through the peripheral openings in the frames, or the assembly may be separated by backing off the follower, allowing the cake to be dumped and the filter medium to be changed.

2. As a precoat filter, in which only wire mesh filter cloth covered leaves are used. The leaves are connected by spacers and are readily separated and moved, making it unnecessary to provide excess leaf spacing to prevent damage from overloading. For further details, circle Number 398 on the Data Post Card.

312 Technical Data Report on Methacrylonitrile. Typical properties, reactions, and discussion of end-use applications. Eastman Chemical Products, Inc.

314 Protective Coatings Bulletins. Data on coatings using phenolic, epoxy resins, and hypalon (chlorosulfonated polyethylene). Made specially for tank linings and for protection of steel, concrete, and wood where corrosive spillage, fumes, and atmospheres are involved. Wisconsin Protective Coating

315 Transparent Plastics. Brochure from Homalite Corp. gives physical and chemical properties of six special clear plastic materials, plus a coating material for emergency repairs.

316 Industrial Insulation Bulletin. Specifications, characteristics, applications of: cements: blocks, blankers, and felts; pipe insulations; other types of insulation. 19page booklet from Baldwin-Hill Co.

317 Information Bulletin on Plastic Specialties. General Plastics Corp. offers data on coatings of Teflon, Kel-F, Gencote 108, Gencote 301, Genton 110, Armalon, other special materials.

318 Amphoteric Surfactants. Technical and product development data from Miranol Chemical Co. on wide line of amphoteric surface active agents. 32-page Bulletin.

319 Chemicals for the Textile Industry.
28-page booklet from Union Carbide
Chemicals Co. summarizes textile applications of organic chemicals. 8 pages of charts
and conversion tables useful in textile research and production calculations. Extensive literature references.

320 Corrosion-Proof Cements, Linings, Coetings. Electro Chemical Engineering and Manufacturing Co. offers a brochure describing their complete services in the field of acid and alkali-proof chemical proccessing equipment.

321 Plastic Materials. Brochure from Wyatt's Plastics, Inc. gives physical and chemical properties of plastic materials available from warehouse stock. Molding and fabrication services also supplied.

322 New Silicone Intermediate. Commercial quantities of Z-6018, a new silicone intermediate that can be polymerized with a variety of organic resins are now available from Dow Corning Corp.



## Better cell operations

The technical skills and experienced know-how of the men who operate mercury cells, are most important factors in low cost chlorine-caustic production.

Equally important is the superior performance of GLC anodes, which are "custom made" to individual cell requirements.

PREE - The cell operation illustrated here has been handsomely reproduced with no advertising text. We will be pleased to send you one of these reproductions with our compliments, Simply write to Dept. R-4.



### GREAT LAKES CARBON CORPORATION

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### MATERIALS

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323 Industrial Solvent. Booklet from Dow Chemical Co. covers properties and uses of Chlorothene (1,1,1-Trichloroethane).

324 New Polyester Lamineting Film. Videne A, recently introduced by Goodyear Tire & Rubber Co., is said to offer "unlimited" end use potential to the textile, metal, wood, paper, plastic, and packaging industries.

325 Reinforced Fluorocarbon Resin, Fluorosint resin, product of Polymer Corp., is said to exhibit a two to fourfold improvement in dimensional tolerances of molded parts over unmodified Teflon, Technical data available.

### EQUIPMENT

326 Technical Bulletin on Venturi Tubes. Comprehensive discussion of the various types of Venturi tubes, their recovery characteristics, the formulas that determine their design, typical calculations, engineering data. Diagrammatic sketches, comparison charts and graphs, installation drawings, dimensional data, capacity tables. Builders-Providence, Inc.

327 New Continuous Digester. Illustrated bulletin from Sprout, Waldron & Co. gives general information, design data, on their new "twin" design-continuous digester for pulp mills.

328 Weather-Protected Motors. Available in all commonly used ratings, both horizontal and vertical, 250 hp and above. Bulletin from Allis-Chalmers.

329 Stainless Steel Fittings. Booklet gives details of Quikupl fittings made by Venton Pump and Equipment Corp. Includes table showing relative effects of more than 330 chemical materials on Neoprene, Butyl, and Thiokol Quikupl seal rings.

330 Vibratory Feeder Catalog. Syntron Cooffers 32-page booklet with complete data and specifications on 13 standard vibratory feeders, 3 hydraulic and/or pneumatic feeders, and on spiral elevator feeders. Many pages of schematic layouts and applications.

331 Portable Oxygen Indicator. Measurer percent of oxygen through a range of 0 to 25% oxygen content with an accuracy of plus or minus 1/2%. Details from Mine Safety Appliances Co.

332 Gate Type High Vacuum Valves. Fullopening design with straight-through unrestricted flow and short flow path. 2,3,4 and 6 in. sizes. Larger sizes to order. Details from F. J. Stokes Corp.

333 Twin-Throat Venturi. Bulletin from Infilco, Inc. gives performence graphs, sizing specifications of new design twin-throat venturi, said to produce higher differential pressure or lower head loss in shorter laying length than other types.

### 399 Submersible Electric Motors.

Reliance Electric and Engineering Co. has introduced a complete line of submersible a-c. electric motors for direct coupling to pumps which must operate continuously while submerged in oil, water, or liquid chemical. The polyphase, single-voltage motors are available in sizes from ¼ through 15 hp. A special universal mounting flange permits direct connection to most standard pumps; modifications can be made to meet special dimensional requirements. They are rated at 55°C temperature rise for 30-minute duty in 40°C liquid. For complete specifications and prices circle Number 399 on the Data Post Card.

### 400 High-Temperature Sealless Plastic Pump.

Handling of extremely corrosive fluids at temperatures to 260°F. is now possible with a new sealless pump developed by Vanton Pump & Equipment. The high temperature limit is attained by the use of Marlex 50 polyethylene as a material of construction. Upper limit for conventional polyethylene is about 140°F. The material is said also to possess a dense molecular structure which results in high tensile strength and low permeability.

permeability.

The Marlex 50 pump line offers a wide variety of inter-changeable plastic body blocks and rubber and synthetic "flexiliners." On these, as on other Vanton pumps, stuffing boxes or shaft seals are eliminated, since flanges on the liners straddle the body block and are pressed to its sides by concentric grooves in the bearing pedestal and cover plate. Capacities in the Marlex 50 line range from ½ to 40 gal/min. For more information, circle Number 400 on Data Post Card.



334 Three-Roll Dispersion Mills. Bulletin from J. H. Day Co. gives specifications and illustrations of construction features on four mill sizes, from leboratory to production models.

335 Precision Dry Materials Feeder. The Vibra Screw feeder provides continuous flow rates from 1 cz. to 100 tons/hr, with models from 1/4 in. to 10 in. diameter. Technical details in bulletin from Vibra Screw.

336 Flow Control Valves. The Micro-Trol valve, product of Valveir Corp., features locked screw adjustment, threaded stem, and molded Nylon flapper. Technical data from maker.

337 Counter Flew Cooling Towers. J. F. Pritchard & Co. offers a brochure with complete engineering details, and design data. Many cross-section drawings.

338 PYC Fume Scrubbers. Bulletin from Schutte and Koerting Co. gives complete details on sizes, capacities, and materials of construction for all scrubbers manufactured by the company.

339 Pyroceram Tubing and Plate. Bulletin from Corning Glass Works describes products now available commercially in their new glass-based, crystalline material of construction.

340 Centrifugal Compressor Catalog. Clark Bros. Co. offers 64-page catalog with complete engineering details, specifications, dimensions, weights of horizontally and vertically-split compressors.

341 Indicating-Controlling Pyrometer. Bulletin from Illinois Testing Laboratories describes the Alnor Pyrotroller, gives complete specifications and typical wiring diagrams showing application to electrically heated, gas- or oil-fired equipment.

342 Fractionating Column Internals. Hendrick Manufacturing Co. specializes in the fabrication of all types of trays and supporting structures to customers' specifications. Bullatin.

343 Globe, Angle, and Check Valves. Brochure from Walworth Co. gives service ratings, dimensional drawings, on their line of



-Photo courtesy Standard Oil Company (N.J.)

### How preheat makes a "30-hour day"

When you add a Ljungstrom® Air Preheater, your onstream stills can give 30 hours of normal production in every 24 hours. That's more than an extra week of production every month!

The reason is that Ljungstroms recover valuable BTUs that are normally dissipated up the stack. By putting this heat back to work, higher flame temperatures are generated, heat transfer rates increased. You can save one barrel of fuel in every five, stay on-stream months longer because slag is virtually eliminated.

LJUNGSTROMS ARE WRITTEN OFF FAST

A Ljungstrom can pay out in nine months or less! The many other advantages show why: use of fuels you formerly threw away . . . more economical furnace design

Wherever You Burn Fuel, You Need Ljungstrom The Ljungstrom operates on the continuous regener-

with no need for convection surfaces . . . minimum slag . . .

shorter turn-around time . . . higher quality product (aver-

Detailed information is available. Learn about Ljungstrom's compactness, easy inspection, simplified cleaning.

minimum maintenance, and the amazing economy and

reliability story. Just call or write the Air Preheater

aging 2 octane numbers higher than previously).

ative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation

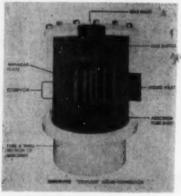


60 East 42nd Street, New York 17, N. Y.

Corporation.

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### DEVELOPMENTS OF THE MONTH (Cont.)



### 401 New Liquid Distributor Head.

A new design graphite liquid distributor head has been developed for falling film type absorbers by Falls Industries, Inc. A liquid reservoir is provided to act as a dampner on any surges of entering liquid, and to force all the liquid to reach the exact same level at the same time. Uniformity of liquid distribution is further assured by baffling the gas inlet to eliminate possible turbulent effects created on the surface of the liquid by the velocity of the entering gas.

entering gas.

Material of construction is impervious graphite, which possesses an exceptionally high rate of heat transfer (1,020 Btu/hr./sq. ft./°F/in., and is unaffected by practically all corrosives except a few highly exidizing agents. For additional information, circle Number 401 on Post Card.

### EQUIPMENT

150-lb. bronze globe, angle, and check valves.

344 Self Priming Centrifugal Pumps. New line made by Standard Pump Division. Worthington Corp., is available in sizes from 11/2 to 8 in. suction and discharge. Featured is new recirculation port design which permits rapid priming and renewal of internal clearance. Bulletins.

345 Portable Cobalt Irradiation Unit. Data sheet from Radiation Applications, Inc. gives details of the Gammalab, a self-contained radiation source standing less than two feet high and holding 62 curies of cobalt-60. Suitable for industrial, school, and governmental laboratories.

346 Duplex Steam-Driven Liquid Pumps. Bulletin from American-Marsh Pumps, Inc., gives performance and dimension charts on twelve sizes.

347 Fluid Control Equipment Catalog. Description and prices of wide range of valves, micron filters, valve accessories. Hoke, Inc.

348 Supervisory Control Equipment Bulletin. Detailed information on description, operation, and application of the Space Code Selector Supervisory System. Charts, pictures, elementary system diagrams, simplified instructions, ratings, dimensions, and line connections. General Electric Co.

349 All Glass Interior Flush Valve. Uses glassed-filled Teflon seat. Designed to fit standard reactor openings. Technical data from Pfaudler Co.

350 High Speed Slurry Pump. Designed to handle suspensions of sand, coal, crystals, silt, sludge, lime, or chemical process slurries. In cast iron, Ni-hard, or stainless steel. Bulletin from Morris Machine Works.

351 Corrosion-Resistant Filter. Shell of 316 stainless steel, uses honeycomb filter tubes ig. Nylon, Orlon, Dacron, Dynel, acetate and glass fibers. Operates at pressures up to 150 lb./sq. in. Technical details from Commercial Filters Corp.

352 Proportioning Pump Bulletin. Describes the McCannameter, available in either diaphragm or bellows construction, with maximum capacities from 6 cu. cm./min. to 6 gal./hr. Maximum discharge pressure is 2,500 lb./sq. in. Hills-McCanna Co.

### DEVELOPMENTS OF THE MONTH (Cont.)

402 Automatic Experimenter.

The Automez, developed by Westinghouse Electric, is a new control device which coordinates the set points of a number of controllers so as to optimize the yield of a process. Says Westinghouse, "the real advantage of Automex is that it can optimize processes in which the relation between input and output quantities is not exactly known. In fact, the characteristics of the whole process may be changing with time due to the influence of uncontrolled variables." Formerly, according to Westinghouse, the existence of these uncontrolled and often uncontrollable variables made conventional controllers inadequate and often made complete investigation of a process prohibitively expensive.

The machine shown in the picture is an experimental model used for demonstration

The machine shown in the picture is an experimental model used for demonstration purposes. For further details of this new development in process control, circle Number 402 on the Data Post Card.



- OCIRCLE your Data Service requests on the handy postcard on page 98 to
- GET up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.

353 Piston Pilot Operated Sciencid Valves. General service valves in rifne sizes from 1/2 to 3 in. Designed for pressures to 400 lb./ sq. in., temperatures to 340°F. Special features are molded epoxy resin waterproof coils, unbreakable piston rings, and guided pilot valve seats. Details from J. D. Gould Co.

354 Polyethylene Ducting Systems. Special catalog "Thermoplastic Cortosion-Proof Ventilating and Exhaust Systems" gives descriptions of all necessary components, explains principles of system design. American Agile Corp.

355 Autometic Gas Sempler. The standard Gilbarco sampler is evailable for line pressures to 350 lb./sq. in., special models up to 2,000 lb./sq. in. Sampling time can be varied from 20 min. down to 10-sec. intervals. Maximum product temperature is 200°F. Technical information from Gilbert & Barker Mfg. Co.

356 Analog Computers for Distillation Calculations. Application bulletin from Electronic Associates, Inc. gives complete theoretical and practical discussion of use of analog computers in steady-state multicomponent distillation calculations.

357 Vertical Sump Pump Brochure. Allen-Sherman-Hoff Pump Co. affers bulletin on the Hydroseal vertical sump pump, aveilable in three types: slurry, sand, and dredge. In three sizes: 1½ to 6 in. suction and discharge. Operates submerged, starts without priming.

358 Azial-Flow Blower-Compressors. Bulletin from CycloBlower Co. gives performance curves, specifications of eight models, capacities from under 100 to almost 3,500 cu. ft./min.

359 Portable Electrolytic Conductivity Recorder. For use in locations where electric power is not available or for temporary means of measurement in chemical process plants. Bulletin from Industrial Instruments, Inc.

360 New Mechanical Mixer. Uses precessional motion of a revolving screw flight moving inside an inverted cone body. Bulletin from Buflovak Equipment Division, Blaw-Knox Co. gives physical dimensions and capacities of six models.

361 Electric Control Systems for Chemical Processes. Frank Electric Corp. specializes in design and fabrication of complete systems and individual panels for process instrumentation and control. Bulletin.

#### ONE OF A SERIES OF ADVERTISEMENTS ON LUMMUS' WORLD-WIDE FACILITIES



Headquarters of SFTL



40,000 B/D Complete Refinery

#### In Paris we are Societé Française des Techniques Lummus

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Phenoi-Acetone Plant



Ethylene Plant



Fluid Catalytic Cracking Unit

Founded in 1948 to serve Continental Europe, Societé Française des Techniques Lummus' specialized technical staff has designed, engineered and constructed scores of the more than 700 Lummus petroleum, chemical, and petrochemical projects throughout the world in the last half century.

SFTL's record includes projects with great variety of size and type. Among recent projects handled by SFTL are pictured above: a complete 40,000 B/D Refinery consisting of nine process units and all offsites, an Ethylene Plant, a Fluid Catalytic Cracking and Gas Recovery Unit and a Phenol-Acetone Plant.

SFTL is also ready to join forces with any one of

six other Lummus offices and subsidiaries - located in New York, Houston, Montreal, Maracaibo, London, The Hague - to make Lummus facilities easily available around the world.

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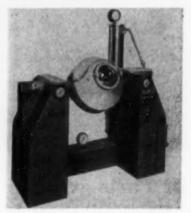
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ENGINEERS AND CONSTRUCTORS FOR INDUSTRY 385 MADISON AVENUE, NEW YORK 17, N.Y.





403 Vacuum Tumble Dryer-Blender.

A new development by the Patterson-Kelley Co. is said to make possible the drying of heat-sensitive meterials in a fraction of the time required by conventional methods. Fast drying in motion is the result of a careful balance of jacket circulation, vapor line and filter, compact piping, condenser, vacuum line and pump, and effective controls.

Fourteen standard models are offered, ranging in capacities from 1 to 150 cubic feet. Charge openings range from 8 to 18 inches, while swing radii range from 10 % to 62 inches. For more technical details, circle Number 403 on the Data Post Card.

#### EQUIPMENT

362 Improved Homogenizer. The Jet-Mogenizer, built by Buschman Products, Inc. is designed to use principles of impact, attrition, turbulence, and ultresonic cevitation to deliver more stable emulsions. Bulletin.

363 Rigid Formed Felt Filter Elements. Folder from McIntire Co. gives engineering data, flow charts, recommended uses, illustrates wide variety of shapes and typical applications.

364 All-Plastic Solenoid Valve. Catalog from Valcor Engineering Corp. gives specifications, application data on line of corrosion-resistant solenoid valves.

365 Large-Capacity Centrifugal Clarifier. The Westfalia KG-10006 clarifier can handle up to 3,000 gal./hr. Liquid contact parts in 304 or 316 steinless steel. Technical details from Centrico, Inc.

#### BASIC THEORETICAL PAPERS

in chemical engineering appear quarterly in the A.I.Ch.E. Journal, published by the American Institute of Chemical Engineers. For further information, circle number 366 on Data Post Card.



## FOR NON-LUBRICATING AND CORROSIVE FLUIDS

You asked for it ...

and Eco is the only manufacturer who has made it available. The first self-priming rotary gear pump suitable for non-lubricating and corrosive fluids is now available for immediate delivery. The pump, with ¾" P.T. inlet and outlet ports, features housings of 316 or Carpenter 20 stainless steel, Hastelloy C or nickel, with reinforced Teflon gears and internal Teflon bearings and packing.

Designated the GearChem, this pump is suitable for speeds to 1750 rpm at capacities to 10 gpm and pressures to 100 psi. Viscous media to 5000 SSU can be pumped at reduced speeds.

The GearChem created tremendous interest at the recent Chemical Show. In addition to proportioning and metering applications the pump is ideal for general process work in pilot plant and production operations.

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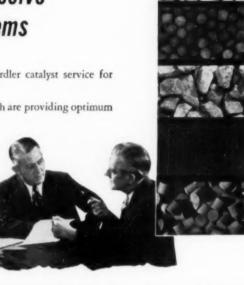
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- There are three important cost-cutting ingredients in Girdler catalyst service for hydrogenation applications:
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Outline your catalyst problem and we will make specific recommendations. Bulletin GC 1256 describes the full line of Girdler catalysts . . . available on request.



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COPPER CHROMITE CATALYSTS	One of most highly active and versatile commercial hydrogenation catalysts. Available in regular and barium-stabilized types either as powder or especially strong pellets. Powder meets certain specific particle density requirements.
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GIRDLER MANUFACTURES CATALYSTS FOR: HYDROGENATION . SYNTHESIS GASES AND HYDROGEN GENERATION . DESULFURIZATION . NEW CATALYTIC PROCESSES

CATALYSTS

from page 108

370 Dry and Paste Mixers. Catalog from Paul O. Abbe details mass and paste mixers. spiral blade mixers, double cone blenders, vertical mixing mills, horizontal mixing mills.

371 Magnetic Flowmeter. Fischer & Porter offer technical information on their new magnetic flowmeter designed for "difficult" liquids such as acids and slurries. Readings unaffected by velocity profile, density, or viscosity.

372 Buyers Guide of Pyrometer Supplies. 52-page catalog from Minneapolis-Honeywell covers their complete line of pyrometer supplies, thermocouple assemblies, and com-

373 All-Purpose Electrical Control. The Versatrol, made by Assembly Products, can control thickness, torque, current, voltage, radiation, pressures, viscosity, pH, light, speed, load. Bulletin.

374 Materials Handling Equipment, Brochure from S. Howes Co. gives details of mixing, screening, classifying and blanding. size reduction, and weighing and packing equipment for the chemical processing industry.

375 Continuous Weigher. Bulletin from Stephens-Adamson Mfg. Co. describes new weigher which will indicate material flow at any moment and will record total weight from starting time to any given moment.

376 Electronic Liquid Level Controller, Type 2408W controller, made by Fisher Governor Co., is designed specifically for use with liquids with a dielectric constant of 80 or more, or a specific conductance of 4 micromhos or more. Bulletin.

377 Centrifugal Pump Selection Data. Guide for specifying corrosion-resistant centrifugal pumps offered by Ampco Metal, Inc., Centrifugal Pump Dept.

378-Piston Type Check Valves. Hoke, Inc. offer new line in brass or type 303 stainless steel. Maximum operating pressure for brass velves is 3,000 lb./sq. in., for SS valves 5,000 lb./sq. in. Temperature limits are 40 to 200°F. Catalog.

379 Wet Classification Equipment Catalog. Describes counter-current classifiers, heavy media separators, hydro-classifiers, hydro separators. Also contains flow sheets on combined grinding and wet classification. Hardinge Co.

380 Self Priming Liquid Ring Pump. Specifications, performance curves, construction data. Bulletin from Goulds Pumps, Inc.

381 Infrared Analyzer Bulletin, Six-page brochure from Beckman/Process Instruments Division, describes Model 15-A for continuous laboratory and pilot plant analysis, and Model 21 for continuous process stream analysis.

382 Grinding and Pulverizing Equipment. 30-page catalog from Bradley Pulverizer Co. has detailed drawings, specifications, capacity, construction and maintenance data on two models of screen-type mills, and three types of pneumatic mills.

continued on page 114



tified applicators, trained and equipped to assure best results.

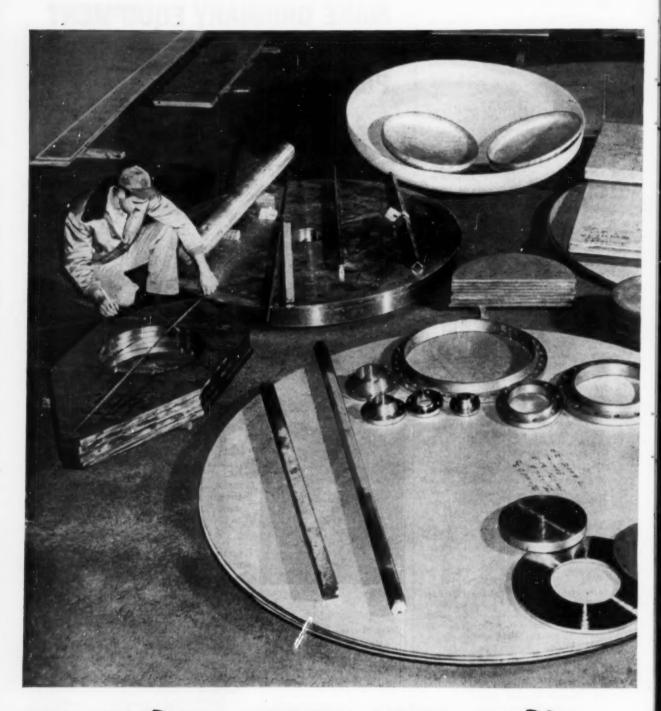
For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses in the U.S. and Canada, or write for Bulletin AD-152.

UNITED STATES GASKET COMPANY Camden 1, New Jersey

United States

Gasket Plastics Division of GARLOCK

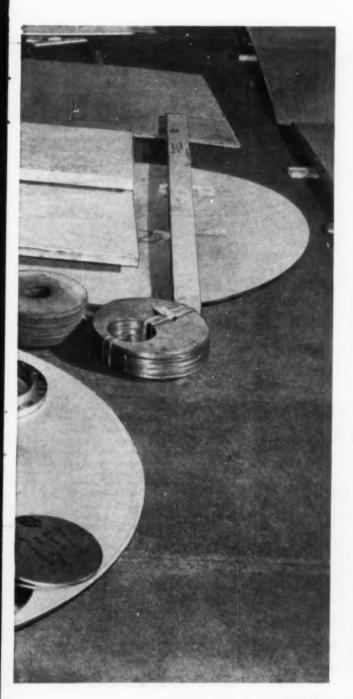




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# Falls Industries is first again... with Comprehensive Data for Cost Estimation of Impervious Graphite Processing Equipment

This 32 page report presents costs and equipment specifications on all the standard impervious graphite processing equipment produced by Falls Industries. Equipment is illustrated with drawings, diagrams or photographs. Costs are tabulated in dollars per square foot of heat transfer surface, or other convenient unit.

Also covered in this report are the famous IMPERVITE impervious graphite Rupture Disk, and the IMPERVITE CROSS-BORE heat exchanger—the most recent exclusive developments of Falls Industries.

The following unsolicited comments are typical of the many received:

"This is exactly the type of information we like to get with costs included."

"It presents the most comprehensive picture of equipment data issued on the subject."

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383 Weather Protected Motors. Designed for outdoor operation under extreme weather conditions. Available in ratings from 250 to 1,500 hp. Complete technical data in bulletin from Louis Allis Co.

384 Automatic Control of Chemical Feeders. Eight-page bulletin from Omega Machine Co. contains schematic diagrams of ten typical control and proportional pacing arrangements, ranging from remote control rate setting to self-checking and self-regulating systems.

385 Valve Selection Data. 56-page catalog from Barksdale Valves covers their complete line of "Shear-Seal" valves, contains graphs for calculating pressure drop, discharge, and velocity of liquids. Also pressure conversion chart scaled from 0 to 3,000 lb./sq. in.

386 Plastic Gas Scrubbing Towers. Tower completely fabricated of Duracor reinforced plastic will resist corrosive gases entering at temperatures up to 300°F. Technical information from Ceilcote Co.

387 Gas Regulator Catalog. 20-page catalog from Linde Co. includes complete specifications and ordering information for 47 Oxweld regulators, available for use with all industrial gases.

388 Corrosion-Resisting Steam Jets. Engineering details, selection data given in brochure from Duriron Co. Special chart shows steam pressure, steam consumption, and liquid volume for different sizes of orfices.

389 Centrifugal Precipitator. A medium efficiency, low-pressure drop centrifugal precipitator for primary dust collectors in pneumatic conveyors and for reduction of dust loading to more efficient final collectors. Bulletin from American Air Filter Co.

390 PVC Self-Lubricating Ball Valve. No metal parts—chemical resistence is equal to high impact rigid Koroseel Grade 300. Technical data from B. F. Goodrich Industrial Products Co.

#### Services

391 Molders Guide to Injection Molding. Two booklets from W. R. Grace & Co., Polymer Chemicals Division, describe basic manufacturing techniques for molding and extruding high density polyethylene.

392 Demineralization Bulletin. Application of demineralizers, basic principles of operation, chemistry of ion exchange resins. Charts on materials of construction and design of component parts. Graver Water Conditioning Co.

393—Pressure Piping and Vessel Codes. 48-page bulletin from Babcock & Wilcox Co. summarizes and correlates specifications of ASA Code for Pressure Piping, B31.1 and B31.1.8-1955, and ASME Boiler and Pressure Vessel Code (Section 1, Power Boilers, 1952, and Section VIII, Unfired Pressure Vessels, 1956). Extensive tables.

394 Sulfur Recovery Process. Bulletin from Tears Engineers describes new sulfur recovery unit, designed to convert H<sub>2</sub>S to high-purity sulfur. Unit is shop-assembled and is ready to operate when connected to source of power and gas supply line.

problem of metering "tricky" liquids eliminated!

### Foxboro WEIGHT-RATE SYSTEM

accurately controls flow rate of any liquid that will pass through a pipe

Here's a Foxboro batch control system designed especially for liquids that undergo wide fluctuations of density, temperature, or viscosity. Small volumes, corrosive liquids — even liquids that stick to the side of a tank will not affect the system's accuracy.

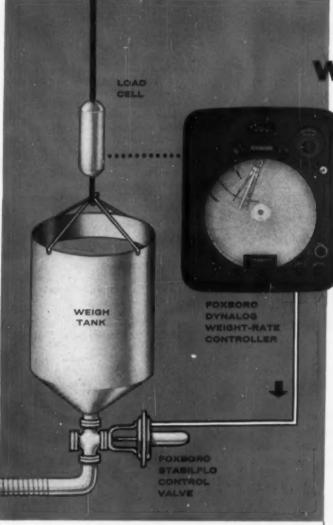
The Foxboro Weight-Rate System controls flow rate by weight of liquid rather than by volume. Functions of a load cell; a Dynalog\* electronic recorder; and a Cyclelog\* pneumatic controller are coordinated to do this.

Operation is simple. You merely set weight of liquid, dial the desired time, and push a button. The automatic control system does the rest, while keeping an accurate record of the whole process.

Best of all, the Foxboro Weight-Rate System requires practically no maintenance. That's because neither the measuring element nor the controller ever come in contact with the process liquid.

If batch operations with "tricky" chemicals are your problem, Foxboro has the answer. Call your local Foxboro Field Engineer for full details, or write The Foxboro Company, 934 Neponset Ave., Foxboro, Mass.

\*Reg. U.S. Pat. Off.



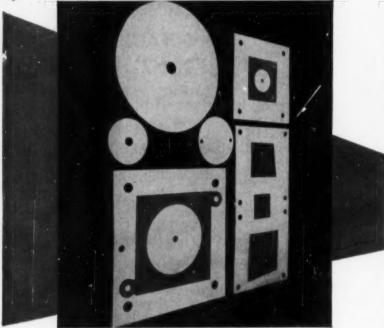
HOW IT WORKS The Foxboro Weight-Rate Flow Control System controls weight of liquid passing from a weigh tank suspended from a load cell (either hydraulic or strain gauge-type). Cell continuously measures decreasing weight of liquid. Controller records weight. controls time of draining, and sends pneumatic control signal to a Foxboro Stabilito Valve installed in drain line. After correct amount of liquid is taken from tank in the desired time, controller automatically closes valve.



FLOW CONTROL SYSTEMS

of A.I.Ch.E.

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E-D filter papers cut to exact requirements of your filter. Above are a few of the most widely used sizes and shapes.

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First, because of their fine porosity. Second, because superior raw materials and rigid production controls result in papers of unmatched purity and quality.

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Time saving: Little or no recirculation is required when used with filter aids.

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Versatile: Can be used with equal efficiency over filter cloth, metal screens, or perforated plates.





REE! Write for new Catalog 357 showing extensive use of industrial filter papers in plant applications.

Newark, N. J., May 6, 1958. Essex House, 1050 Broad St., Joint One-day Meeting on Catalysis and Solids--Liquid Separation, New Jersey A.I.-Ch.E. and No. Jersey Chemical Engineer's Club. Chmn.: John M. West, Squibb & Sons, Georges Rd., New Brunswick, N. J. Catalysis and Catalytic Reactions-A. G. Oblad, M. W. Kellogg Co., Catalytic Advances in Polymerization-C. Schildknecht, Stevens Inst. Catalysts in Petroleum Refining-L. P. Evans, Socony. Catalysis with Platinum Group Metals - G. Cohn, Engelhard, Ind. Handling Solids-Liquid Separation Problems-J. C. Smith, Cornell Univ. Equipment Selection & Applications of Batch Filtration-C. A. Jahreis, T. Shriver & Co. New Developments & Applications of Continuous Filtration-D. A. Dahlstrom, The Eimco Corp. Centrifuging in Chemical Processes-J. T. Costigan, Sharples.

Toledo, Ohio, May 9, 1958. Commodore Perry Hotel. One-day meeting of Ohio, Pittsburgh, and Detroit Sections, A.I.Ch.E. Theme, "Instrumentation for the Chemical Engineer."

Berkeley, California, June 19-21, 1958. Dwinelle Hall, Univ. Calif. 1958 Heat Transfer and Fluid Mechanics Institute. Co-sponsored by A.I.ChE. & other groups.

Philadelphia, Pa., June 22-27, 1958. Bellevue-Stratford Hotel. 50th Anniversary Jubilee Meeting of A.I.Ch.E. See further details on pages 152-3.

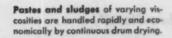
Evanston, Ill., August 18-21, 1958. A.I.Ch.E. - A.S.M.E. Heat Transfer Conference, Northwestern U. Technological Inst. Tech. Prog. Chmn.: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.

Salt Lake City, Utah, Sept. 21-24, 1958. Hotel Utah. A.I.ChE. National Meeting. Gen. Chmn.: R. J. McNally, Amer. Smelting and Refining, Salt Lake City, Utah. Tech. Prog. Chmn. and General Papers: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City. Air Pollution-W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California. What's New in Liquid Metals Technology-Marshall Sittig, American Lithium Institute, Inc., P.O. Box 549, Princeton, N. J. Crystallization-H. M. Schoen, American Cyanamid Co., 1947 West Main

continued on page 118



Molten materials, often repelled by smooth drum surfaces, are successfully handled on grooved drums.







Heavy or dilute liquids respond well when dried on equipment specifically designed for the process.

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Five different types of drum dryers are just part of a complete line that includes atmospheric and vacuum types, with chamber, pan, rotary, spray and other models.

Backed by this complete line, Buflovak experienced engineers can *impartially* recommend the unit that meets known specifications . . . fulfills the requirements of individual product testing.

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An extensive line of small scale and pilot-size equipment is at your service for investigating drying, evaporation, extraction, impregnation and crystallization problems. Here you obtain accurate data and actual samples of your processed product, examine operation efficiency... thoroughly explore by-product possibilities.

Catalog 380 describes the Buflovak Dryer line; Catalog 381 fully describes Buflovak's lab. Both are available at your request. Additional facts also available in C. E. Catalog, pages 429 to 452.

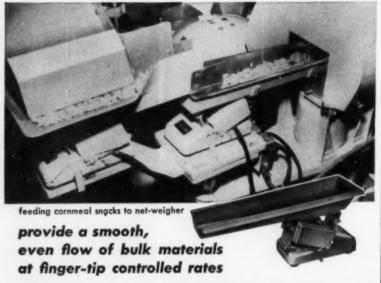


#### BLAW-KNOX COMPANY

Buflovak Equipment Division 1567 Fillmore Avenue, Buffalo 11, New York

from page 116

#### VIBRATORY FEEDERS



SYNTRON "Vibra-Flow" Vibratory Feeders fill the gap between storage and processing. They provide a smooth, even flow of bulk materials—hot or cold, dry or damp, from powders to chucks—to mixers, batchers, driers and other processing equipment. And, the flow rate is instantly adjustable, from minimum to maximum to meet production schedule changes.

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Investigate the production possibilities with SYNTRON Vibratory Feeders in your operation. Send us the details of your problem—our application engineers will be glad to submit recommendations.

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designed to increase production, cut production costs, improve products

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St., Stamford, Conn. Foams and Froths-J. Louis York, Dept. of Chemical Engineering, Univ. of Mich., Ann Arbor, Mich. Ethylene-Hermann C. Schutt, 201 Devonshire Street, Boston. Mass. Polar-Nonpolar Thermodynamics-J. M. Smith, Dept. of Chem. Eng., Northwestern Univ., Evanston, Ill. **Economics of Non-Petroleum Sources** of Energy-J. M. Hirsch, Gulf Research & Dev. Co., P.O. Drawer 2038, Pittsburgh 30, Pa. Centrifugation-J. O. Maloney, Univ. of Kansas, Law, rence, Kansas. Intermountain Industries-W. C. Bauer, Intermountain Chem. Corp., Box 872, Green River, Wyoming. High Temperature Chemical Kinetics and Transport Phenomena-W. R. Marshall, Univ. of Wisconsin, Madison, Wis. Dry Classification of Solids-D. W. Oakley, Metal and Thermit Corp., 100 Park Ave., New York, N. Y. Safety in Air and Ammonia Plants-N. H. Walton, Atlantic Refining, 3144 Passyunk Ave., Philadelphia 1, Pa. Improved Utiliza-tion of Technical Manpower-J. F. Cheely, Ethyl Corp., Box 341, Baton Rouge, La. Petroleum Refining-L. W. Russum, Standard Oil Co. (Indiana), Whiting, Ind. Hydrometallurgy-Chemistry of Solvent Extraction-G. H. Beyer, Chem. Eng. Dept., U. of Mo., Columbia, Mo. Alternate Energy Sources-H. F. Nolting, Std. Oil Co. (Ind.), 2400 New York Ave., Whiting,

Deadline for papers, May 21, 1958.

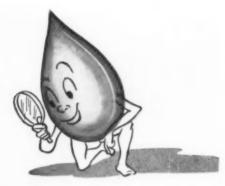
Cincinnati, Ohio, December 7-10, 1958. Netherland Plaza Hotel. A.I. Ch.E. Annual Meeting. Genl. Mtg. Chmn.: T. B. Wiehe, Schenley International. Tech. Prog. Chmn.: A. C. Brown, Emery Industries, Inc. June & Long Sts., Ivorydale, Ohio. Pollution Control by In-Plant Measures - C. Fred Gurham, Dept. of Chem. Eng., Michigan State U., East Lansing, Michigan. A.I.Ch.E. Research on Bubble Cap Tray Efficiency-W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. High-Speed and Time-Lapse Photography in Chemical Engineering-J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. Kinetics & Rate Processes-H. E. Hoelscher, Dept. of Chem. Eng., John Hopkins Univ., Baltimore 18, Md. Reprocessing of Fluid Reactor Fuels-O. E. Dwyer, Chem. Eng. Div., Brookhaven National Laboratory, Upton, L. I., N. Y. The Application of Computers to Heat and Mass Transfer

continued on page 120

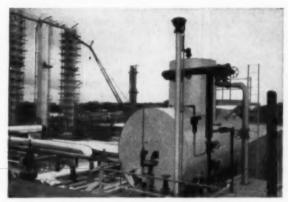


Pilot tray-type deaerator shown with continuous oxygen analyzer in test setup.

#### ALLIS-CHALMERS DEAERATORS



## Looking for more effective deaeration?



Outdoor installation of Allis-Chalmers decerator in southern chemical plant.

.

Heating and distributing tray zone

Decerating tray zone

●If so — you'll be interested in the continuing research program at Allis-Chalmers to evaluate all factors in the design of deaerators.

This program includes the use of a specially built pilot deaerator with automatic oxygen analyzer and recorder. Operating factors and deaerating compartment design can be varied to study length of spilling edge of trays, heating area and method of flow. Results obtained with this setup are quickly translated into deaerators designed for optimum performance.

In addition to this continuous testing, metallurgical research is being done to select the most suitable materials.

Over 30 years' experience in the field of power plant water conditioning, and over 75 years' experience in the field of steam power plant equipment including deaerating-type condensers, provide further valuable background. No other manufacturer so completely insures deaerator performance.

For further information contact your nearby A-C office or write for Bulletin 28B8853, Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wis.

Overflow

Cross section of tray-type deaerator shows water and steam flow.

Pump suction outlet

**ALLIS-CHALMERS** 



from page 118

If you are handling corresives or require contamination - proof piping — you need Doré Teflon Lined Piping and Fittings.

## NOW TEFLON LINED PIPE AND FITTINGS !



**TEFLON LINED TEES \* \*** have a solid, weldless liner. Sizes 1" through 6".



TEFLON LINED ELLS \* \* are available in sizes I" through 6".

Doré, the leading molders of "Quality Controlled" Teflon Shapes, are now applying their skill and integrity to the fabrication of Teflon lined pipe and fittings.

The pure, white\* Teflon lining is tough, dense, hole-free-has no welds. The Teflon seals, made by forming the liner over a raised flange face, is perfectly flat and smooth not wavy. It covers the entire raised face and eliminates the use of an extra flange gasket. Doré Teflon lined pipe and fittings provide corrosion-free, contamination-proof piping for an extremely wide range of commodities.



TEFLON LINED PIPE is available in sizes I" through 6" - lengths to 10' with welded flanges.

Pressure Rating 400 psi Vacuum Rating Full Vacuum Temperature Rating -90°F. to 400°F

The Teflon seal lies flat, and smooth on the raised flange face. No extra gasket is needed for a perfect, protective seal.

DuPont Tetrafluoroethylene Resin. \*Only virgin Teflon is white. \*\*Patent Pending.

John L. Dore, Co.

SALES AGENTS IN U.S.A. FOR JOHN L. DORE, INC.

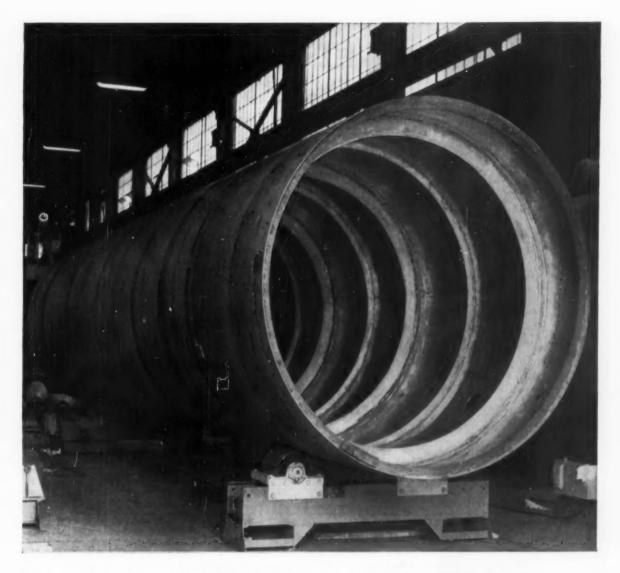
Du Pont's Teflon - Hi Quality Nylon

5406 SCHULER . P. O. BOX 7772 . HOUSTON 7, TEXAS

Computer Control of Processing Units -D. M. Boyd, Universal Oil Prods., 30 Algonquin Rd., Des Plains, Ill. Startup of New Chemical Plants— M. L. Nadler, DuPont, Penns Grove, N. J. Care and Feeding of Executives -I. S. Wilson, Heidrick & Struggles, 20 No. Wacker Dr., Chicago 16, Ill. Mechanics of Fluid-Particle Systems-S. K. Friedlander, Columbia U., New York 27, N. Y. Process Data & Design Methods for Nuclear Fuel Recovery-C. E. Stevenson, Rsch. Dir., P.O. Box 1259, Idaho Falls, Idaho. Thermodynamics of Phase Equilibria-E. M. Amick, Jr., Chem. Eng. Dept., Columbia U., New York 27, N. Y. Market Research & the Chemical Engineer-William Copulski, Grace R&D Co., 3 Hanover Sq., New York 4, N. Y. Deadline for papers: November 16,

Kansas City, Missouri, May 17-20, 1959. Hotel Muehlebach. A.I.Ch.E. National Meeting. Gen. Chmn.: F. C. Fowler, Consulting Chem. Engr., 7515 Troost Ave., Kansas City, Mo. Tech. Prog. Chmn.: Fred Kurata, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kansas. Reaction Kinetics-R. R. White, Dept. of Chem. Eng., Univ. of Michigan, Ann Arbor, Mich. How to Become a More Proficient Technical Engineer. Heavy Chemicals - N. J. Ehlers, Columbia - Southern Chem. Corp., 1 Gateway Center, Pitts. 22, Pa. Petrochemicals - G. E. Montes, Nat'l. Petrochemical Corp., Tuscola, Ill. International Licensing and Collaboration-R. Landau, Scientific Design Co., 2 Park Ave., New York, N. Y. **General Papers** (2 sessions), J. O. Maloney, Univ. of Kansas, Lawrence, Kan. and Merk Hobson, Univ. of Nebraska, Lincoln, Nebr. Non-Equilibrium Fluid Mechanics-M. J. Rzasa, Cities Service Res. Lab., P.O. Box 402, Cranbury, N. J. Multiphase Flow in Pipes and Annuli-C. S. Kuhn, Magnolia Petroleum Co., 907 Thomasson Dr., Dallas, Tex. Thermodynamics of Jet & Rocket Propulsion-G. C. Szego, Gen. Elect. Aircraft & Gas Turbine Div., Cinn. 15, Ohio. Deadline for papers: January 17, 1959.

Atlantic City, N. J., March 16-20, 1959. A.I.Ch.E. National Meeting. Chalfonte Haddon Hall Hotel. Gen. Chmn.: J. D. Stett, Dept. Mech. Eng., Rutgers Univ., New Brunswick, N. J. Tech. Prog. Chmn.: N. Morash, Nat'l. Lead Co., P.O. Box 58, So. Amboy, N. J.



#### For Storage at 297° Below... Under Vacuum

Liquid oxygen is cold stuff. Boiling at 297° below zero, it must be contained in a thoroughly insulated vessel to prevent intolerable evaporation losses. This 9′ x 40′3″ section, of Type 304 stainless, is the inner compartment of a giant vacuum bottle for liquid oxygen storage. To assure a perfect vacuum, the welds must remain tight over a wide range of temperatures, requiring extreme care in selection of materials and laying in of welds. Applying experienced craftsmanship to such fabrication problems as this is nothing new at Graver. Many years of cryogenic research assures a safe, trouble-free, low-temperature vessel that will give long service. At whatever temperature your product must be stored or processed, you will find the type of custom fabrication you require at Graver.



Building for the Future on a Century of Craftsmanship in Steels and Alloys

#### GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

New York • Philadelphia • Edge Moor, Delaware • Pittsburgh Detroit • Chicago • Tulsa • Sand Springs, Oklahoma • Houston New Orleans • Los Angeles • Fontana, California • San Francisco



The unique design of the new VARI-FLO stopcock offers many distinct advantages over conventional stopcocks. The plug turns on a micrometer-like screw thread which makes precision flow control

possible. The all-glass body is inert to most liquids and gases. The strong torque of the screw action eliminates freezing and "stickslip" operation. One VARI-FLO covers the range of stopcock sizes from 0-4 mm.

As illustrated at right, the VARI-FLO has a cylindrical plug which engages the barrel by means of an external thread arrangement. The plug is encircled by a small groove which replaces the conventional plug bore. The control of flow is determined by the alignment of this groove with the inlet and outlet of the stopcock.

flow is deteris groove with opcock.

tails,

PLUG

For more complete details, write for Bulletin 101.

WILMAD GLASS CO., INC.

Said to be the first large organic chemical plant to be announced in 1958, Wicco Chemical's new 20 million lb./yr. phthalic anhydride plant in Chicago is slated for completion by early 1959. Design and construction will be by Scientific Design of New York.

A new executive, sales and technical headquarters for the Ciba Co. is being built at Fairlawn Industrial Park, Fairlawn, N.J. Special emphasis is being placed on the design and equipment of technical laboratories and related facilities.

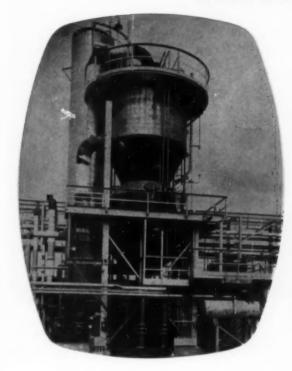
Negotiations have been broken off in the projected combination of Consolidated Electrodynamics Corp. and Cenco Instruments Corp. No detailed explanation has been offered. #

Pennsalt Chemicals has sold all the assets and business of its I.P. Thomas Division, except a 70-acre tract at Paulsboro, N.J., to Dixon Chemical Industries, Inc. The Paulsboro land is where the Thomas fertilizer plant is located and this will be leased to Dixon with an option to buy. The decision of Pennsalt to sell was brought about by an evaluation of the company's long-range objectives which indicated that the manufacture and sale of commercial fertilizers is not a logical field for Pennsalt. #

Five marketing functions have been consolidated into an expanded market development department at Monsanto's Plastics Division in Springfield, Mass. #

A \$460,000 Government contract to design, construct and test operate a large vacuum "skull" furnace for melting titanium has been awarded to National Research Corp., Cambridge, Mass. The quarter-ton capacity furnace is expected to provide valuable information and assist in developing specialized mass production techniques essential to the nation's rapidly expanding scientific programs. Although the Government contract calls for using the furnace on titanium only, it will also be studied for use with other difficult to handle materials that can be produced in large quantities such as uranium, zirconium, thorium, cobalt, and many of their alloys. The unit will develop temperatures more than one-third that of the surface of the sun, and will contain about one-millionth the air pressure of the atmosphere.





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#### PLUS . . . Operating Economies

STRUTHERS WELLS KRYSTAL Crystallizers assure you not only product superiorities but operating advantages that include: lower centrifuging costs; less processing; dust elimination; lower drying costs; a free-flowing product; minimum caking and many other time and money-savers. Write now for Bulletin CE-57.

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#### STRUTHERS WELLS CORPORATION

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Representatives in Principal Cities

Plants at Warren, Pa. and Titusville, Pa.

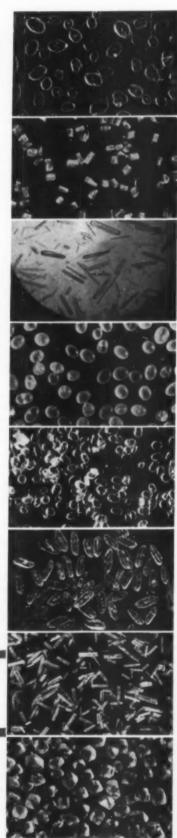
PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units FORGE DIVISION

Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening & Back-up Rolls



#### Coral Rubber vs Natural Rubber

## A comparison of chemical and physical properties

With five companies vying to develop a synthetic rubber to replace natural rubber (CEP, Feb. '58), and Coral rubber (Firestone's cis-polyisoprene) reported as all but identical to natural rubber (CEP, Mar. '58), CEP presents here details of the recently released Quartermaster R&D Command's comparative tests of Coral and natural rubber.

Three major rubber companies\* have announced methods for polymerizing cis-polyisoprene, the basic material of natural rubber, into what have come to be called synthetic natural rubbers. In order to determine just how closely these cis-polyisoprenes do resemble natural tree rubber in physical and chemical properties, the Quartermaster R&D Command, Chemicals and Plastics Division, acquired from Firestone a sample of Coral rubber. Here are the results of these tests.

#### Test Results

Five pounds each of Coral rubber and natural rubber were cured identically—60 minutes at 280°F. Half of the test pieces were then aged for 70 hours at 212°F. Both materials were compounded using the following recipe: polymer, 100; zinc oxide, 6; stearic acid, 4; sulfur, 3; captax, 0.5; santoflex BX, 1; and carbon black, 50. Standard Federal Test methods, and ASTM designations, were used.

The physical properties, abrasion index, compression set values and Yerzley results at room temperature were remarkably similar for the two rubbers. Differences may be attributed to normal experimental variables, or to compounding variables.

Tear strength of unaged Coral was

Tear strength of unaged Coral was inferior to that of unaged natural rubcontinued on page 126

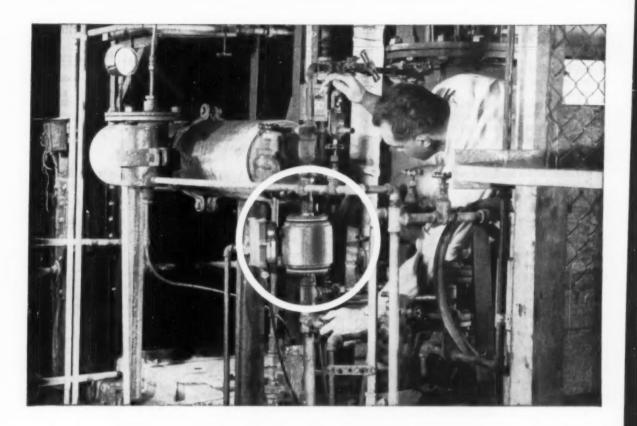
PROPERTIES OF CORAL AND NATURAL RUBBER AT
ROOM TEMPERATURE

	Una	aged	Aged 70 h	rs./212°F.
Physical Properties	Coral	Natural	Coral	Natural
Tensile, lbs./sq. in	3300	3390	1300	1150
Ultimate Elongation, %	560	560	245	260
Stress, 300% clongat'n, lbs./sq. in	1500	1500		
Hardness, Shore A	59	58	59	56
Tensile Loss, %			60.6	66.1
Abrasion Index	244	199	198	200
Compression Set, 24 hrs., %				
10-second reading	11.4	13.8	11.9	12.9
30-minute reading	6.2	6.9	6.3	5.8
Resilience, Oscillograph, Yerzley				
Resilience, %	69	70	66	66
Static Modulus, 20% deformation,	1000	850	950	850
lbs./sq. in	180	160	160	160
Frequency, cycles/sec	4.4	4.2	4.5	4.1
Effective Modulus, lbs./sq. in	1575	1320	1530	1270
Kinetic Energy in Elastomeric Spring, inlbs./cu. in	63	51.2	50	49.6
Energy to produce 20% Deforma-				
tion, inlbs./cu. in	18	16	16	16
Set, inches	0.007	0.005	0.001	0.006
Tear Strength, Ibs./in.				
Die B	466.2	617.8	180.5	86.9
Die C	231.2	480.3	78.6	58.2

#### PROPERTIES OF CORAL AND NATURAL RUBBER AFTER LONG-TERM CONDITIONING AT -65°F.

COND	HIONING	A1 -00 F.		
	Un	Unaged		lrs. at 212°F.
	Coral	Natural	Coral	Natural
Gehman Relative Modulus				
1 Day	14.8	8.3	33.9	22.4
7 Days	22.3	11.1	55.3	35.2
28 Days	37.7	20.5	164.7	48.2
Tension Recovery, %				
10 Seconds				
1 Day	3	4	5	3
7 Days	8	1		3
28 Days	3	0	2	0
30 Minutes				
1 Day	20	10	11	10
7 Days		8	20	12
28 Days	15	0	10	2
Compression Set, %				
10 Seconds				
1 Day	93	93	93	92
7 Days	97	96	97	97
28 Days	95	96	95	96
30 Minutes				
1 Day	72	73	87	78
7 Days	87	83	93	89
28 Days	84	88	92	87

Firestone with Coral rubber, Goodrich with Ameripol SN, and Goodyear with Natsyn.



#### Chempump aids research program

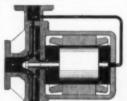
#### handling sulfate liquor at St. Regis Paper Co.

Hot, black sulfate liquor is pumped into experimental digesters by this *Chempump* at St. Regis Paper Company's plant at Tacoma, Washington. Unlike conventional pumps, the *Chempump* is leakproof and virtually maintenance free . . . features that eliminate downtime and help speed the company's research program.

This Chempump can't leak, for it is a totally enclosed unit—no seals, no stuffing box, no packing. External lubrication is never required, as bearings are con-

stantly lubricated by the pumped fluid itself. Extremely compact, the *Chempump* mounts right in the pipeline.

Where you require dependable, leakproof pumping, put a *Chempump* on the job. You'll profit considerably from its many advantages. For details concerning your specific application, write to Chempump Corporation, 1300 E. Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.



Chempump combines pump and motor in a single, leakproof unit. No shaft sealing device required.

U.L. approved. Available in a wide choice of materials and head-capacity ranges for handling fluids at temperatures to 1000 F. and pressures to 5000 psi.



First in the field...process proved

#### Rubber vs Rubber

continued from page 124

ber, but after aging this reversed, indicating that this property may be controllable.

In general, unaged Coral showed superiority over unaged natural rubber in chemical resistance, low-temperature properties, and set under tension or compression. Unaged natural showed superiority in low temperature stiffness. When aged, the two rubbers showed much greater similarity in all properties, and at  $-65^{\circ}F$ . the two rubbers showed considerably less difference than at  $-30^{\circ}F$ .

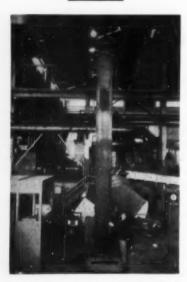
General conclusions drawn from the tests by Quartermaster R&D were:

 The compounded Coral rubber tested was practically identical to natural rubber in physical properties and aging characteristics.

2) The low temperature behavior of Coral under stress was slightly better than that of natural rubber.

3) The low temperature stiffening of Coral when not under stress was slightly superior at  $-30^{\circ}$ F. but slightly inferior at  $-65^{\circ}$ F.

\* Gehman Torsion Test: A 1.625 x 0.125 x 0.079-in. test piece is connected in series with a torsion wire 2.38 in. long so that, when the torsion axis is turned 180°, the twist is distributed between the wire and the sample in a manner which depends on 'he modulus of the rubber.



The world's first commercial unit to continuously cast tough pitch copper cakes is shown in operation at the Perth Amboy, N. J., refinery of American Smelting & Refining Co. Asarco's new process casts this 25 ft. long cake weighing over 17,000 pounds.

#### CHEMICAL RESISTANCE OF CORAL AND NATURAL RUBBER (In Fluid III\*, 48 hrs. at 75°F.)

	Unag	ed	Aged 70 Hrs. at 212°F.		
	Coral	Natural	Coral	Natural	
% Vol. Swell	197.3	213.8	165.3	178.6	
Tensile, lbs./sq. in	330	490	110	100	
% Ultimate Elongation	110	140	50	45	
% Tensile Loss	90.0	85.6	91.5	91.3	

<sup>\* 70/30</sup> by volume, iso-octane/toluene.

#### LOW TEMPERATURE TESTS OF CORAL AND NATURAL RUBBER (°F.)

	Unaged		Aged 70 Hrs. at 212*	
	Coral	Natural	Coral	Natural
Brittle Point	-67	-70.6	-56.2	-67
Gehman Relative Torsional Module	us*			
T2	-32.1	-29.7	- 1.5	+ 0.3
T5	-49.5	-53.9	-33.9	-35.1
T10	-56.5	-61.0	-46.7	-48.6
T100	-69.7	-78.9	-64.8	-71.7
Tension Retraction				
Original Extension®				
TR 10	-69.6	-68.4	-67.4	-68.3
TR 30	-61.4	-34.3	-52.6	-48.3
TR 50	-54.7	+13.7	-40.4	-27.9
TR 70	-44.3	+29.1	-26.7	-1.5
Original Extension ••				
TR 10	-70.8	-56.7		
TR 30	-58.9	+19.9		
TR 50	-50.4	-33.4		
TR 70	-40.7	40.6		

At 150%, except aged natural rubber, which was 140%.
 At 250%.

#### PROPERTIES OF CORAL AND NATURAL RUBBER AFTER LONG-TERM CONDITIONING AT -30°F.

	Ur	naged	Aged 70 Hrs. at 212°F.		
Cl. Pl. Will	Coral	Natural	Coral	Natural	
Gehman Relative Modulus					
1 Day	1.2 1.6 1.6	1.5 18 44	2.3 2.2 2.4	2.5 3.0 2.5	
Tension Recovery, %					
10 Seconds 1 Day	49 52 54	1 0 0	27 25 33	10 5 5	
30 Minutes 1 Day	89 81 85	4 0 2	63 50 63	17 9 7	
Compression Set, %					
10 Seconds 1 Day 7 Days 28 Days •	60 60 62	70 100 100	78 74 81	65 75 82	
30 Minutes 1 Day 7 Days 28 Days •	28 28 26	52 100 100	35 34 34	37 44 63	

<sup>\*</sup> Cold box failed at beginning of 28th day and temperature rose to -20°F, for 6 hours. Temperature was returned to -30°F, and held for 4 hours. Then run.



## Made to pass the severest tubing test of all

#### 14 different tests have proved it now ready for reactor use

\*Superior tubing for applications in the atomic energy field is usually produced to meet highly exacting specifications. A length of tubing like the one shown above may well undergo all the tests and inspections listed here-plus special ones required by the customer.

- Visual surface check
- Dimension check (using precision measuring instruments)
- 3. Hydrostatic test
- Eddy current inspection Tensile and elongation test
- Rockwell hardness test
- Flare & flatten test
- Dye penetrant (over entire length of tube)
- 9. Metallographic mount (for checking analysis, temper, grain size and structure)
- 10. Quantitative and qualitative
- analysis

  11. Corrosion tests (Huey, salt spray, Strauss, autoclave, etc.)
- Spectroscopic examination
- 13. X-ray inspection 14. Ultrasonic inspection

We offer many special services, and of our more than 120 available analyses, many are important to atomic tubing users. Equally important are such factors as our ability to produce tubing to extremely close tolerances; the weldability of the stainless and zirconium and nickel base alloy tubing we supply; and our ability to supply stainless alloys and other materials with very closely controlled chemical composition (Type 348, for example, with cobalt held to .10 maximum).

For more information, write us, giving such pertinent facts as the alloys in which you are interested and the end use of the tubing. We will be glad to send you Data Memorandum No. 20, "Tubing for Atomic Power." Write Superior Tube Company, 2011 Germantown Ave., Norristown, Pa.

NORRISTOWN, PA.

All analyses .010 in. to % in. OD-certain analyses in light walls up to 21/2 in. OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

# Great Performance!

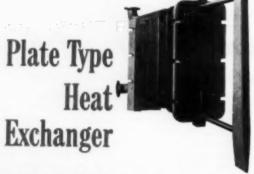


Whatever your heat exchange applications, the chances are that one of the high-performance exchangers that we manufacture can do the job for you. Here are two principal types:



### Spiral Heat Exchanger

The Spiral Heat Exchanger is a compact assembly of two rolled-up plates that form two concentric spiral passages of rectangular cross-section. Its features are: full-counterflow; long pass; high turbulence; excellent scrubbing permitting use of low fouling factors on each side; access to each side; low radiation losses. In operation, the hot fluid flows from the inside outward and the cold fluid flows toward the center. Thus, true counterflow is achieved.



Extremely high heat transfer is obtained in a plate exchanger. Heretofore, this type has been limited to moderate pressure services, but the Rosenblad plate exchanger is a rugged assembly developed for industrial services up to 175 p.s.i.g. The contained gaskets will not blow out at 300 p.s.i.g., and it is impossible to deform the plates under any operating and surge pressures. The rugged internal structure of the plates is due to the herring-bone patterned corrugations. For full information on these units, write:

### American Heat Reclaiming Corp.

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Representatives in principal cities

Ten years of progress at Case Institute of Technology are outlined in the novel "ten-year annual report" just issued by the institution. In these last ten years Case has more than doubled its floor space on campus, and full-time faculty members have in-creased from 132 to 189, with total faculty growing from 202 to 287. At the same time the number of faculty members holding doctorates has increased from 28.5 per cent to 51.5 per cent, and those holding only bachelor's degrees has decreased from about 31.2 per cent to 16 per cent. There has been a marked increase in the level of faculty salaries-maximum professorial salaries are now \$12,500 instead of

The Sixth International Congress on Large Dams will be held in New York City, at the Statler Hotel, September 16-20, 1958. Following the Congress, three tours of the country's major dam sites have been arranged. For information consult bulletin No. 1 of the United States Committee on Large Dams, c/o Engineers Joint Council, 29 West 39th Street, New York 18, N. Y.

Fifth Annual Conference for Engineers and Architects, sponsored by Ohio State University College of Engineering, is scheduled for Friday, May 2, on the Columbus, Ohio, campus. Principal speaker will be Maj. Gen. John B. Medaris, commanding general of the U.S. Army Ordnance Ballistic Missile Corps' Agency. Huntsville, Ala. In the afternoon, joint technical sessions will be held, all sponsored by more than one department, and all running concurrently. The chemical engineering department will join with the mechanical and the welding engineering departments to present discussions in the field of Nuclear Engineering.

Greece will receive \$350,000 from AEC toward the cost of a nuclear research reactor project near Athens.

An advanced summer course on Chemical Processing with nuclear energy will be presented at Hanford Laboratories from June 22 to August 15, 1958, under the joint auspices of the American Society for Engineering Education and AEC. The course is limited to 20, a "Q" clearance is required. Details from ASEE or any engineering department credited by ECPD.



#### News trom

#### **National Carbon Company**

Division of Union Carbide Corporation - 30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. In Canada: Union Carbide Canada Limited, Toronto

#### National Carbon representatives expand your engineering force



L. E. BRUGMANN, SALES ENGINEER

Mr. Brugmann was graduated from Purdue University with a B.S. Degree in Chemical Engineering. For three years he worked in the midwest as a process engineer with a large chemical company. His work covered development of new chemical processes and the improvement of existing processes, both from the technical and economical aspects of the process. It was necessary for Brugmann to know the required equipment thoroughly, to work on the design of new equipment and to draft an economic evaluation of any changes.

Mr. Brugmann has been with National Carbon Company since 1954. His first two years were spent in the Cleveland Office working up Engineering Proposals on incoming inquiries from chemical and allied industries. He has been a field engineer covering the west coast since 1956. Call your National Carbon Sales Engineer today.

# "KARBATE" PUMPS HANDLE A WIDE RANGE OF CORROSIVE SERVICES EFFICIENTLY AND ECONOMICALLY



This carload of "Karbate" pumps was shipped to a major rayon producer.

During the past twenty years, "Karbate" impervious graphite pumps have gained an envious performance record corrosion wise. A recent survey on service applications indicates these pumps handle a wide variety of corrosives over a wide temperature range. Some of these solutions are: hydrochloric acid, all concentrations; phosphoric acid — up to 75%; sulphuric acid from 1 to 93%; chlorinated hydrocarbons such as benzene hexachloride, monochloracetic

acid, DDT; mixed acids such as nitrichydrofluoric, sulphuric-hydrofluoric, hydrofluoric-chromic oxide, chromicnitric hydrofluoric, phosphoric-hydrochloric nitric; chlorinated sodium and potassium chloride brines, ferric chloride; caustic; chlorine saturated water.

The excellent corrosion resistance of "Karbate" pumps permits a given plant to utilize one type pump for all corrosive services. Such a pump standardization means a saving in pump parts inventory, and also means lower maintenance costs due to greater proficiency in handling one type pump.

#### "KARBATE" PUMPS FEATURE LOW MAINTENANCE COSTS

A rayon manufacturer reports using "Karbate" impervious graphite pumps to handle rayon spin bath solutions. Maintenance costs on each pump were \$25.00 the first year and \$25.00 the second year costs on an alloy pump were \$25.00 the first year and \$500.00 the second year.

A major chlorine producer is

using "Karbate" impervious graphite pumps to handle chlorinated cell brines. Eighteen pumps are in service. Maintenance costs on the "Karbate" pumps are approximated at \$100.00 per pump per year as compared to costs on another non-metallic type pump of \$500.00 per pump per year.

. . .

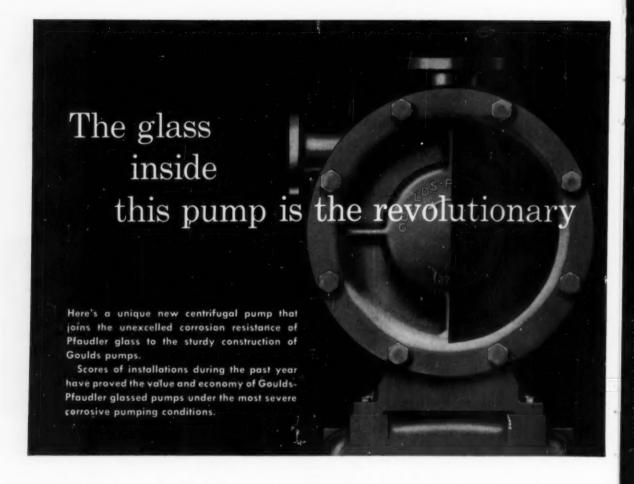
#### "KARBATE" PUMP TABLE OF SIZES AND CAPACITIES

Pump size Suction Discharge			Motor-Mounted Type F	Frame-Mounted Type C	
2	X	1V2	29-FAL	11/2-CB	
3	X	2	19-FAL	2-CA 2-CB	
4	X	3	-	3-CA 3-CB	
6	x	4	-	4-CA	



The terms "National", "N" and Shield Device, "Karbate" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.





There are 6 important reasons for calling this new pump revolutionary in its usefulness to anyone pumping corrosives.

1. Corrosion resistance. Every pump surface that touches the pumpage is glassed. The borosilicate glass formulated specifically for pump application does not depend upon a passivating film for protection. It therefore offers excellent corrosion resistance to all acids (except hydrofluoric) even at elevated temperatures to 350° F. and to alkalies at moderate temperatures.

This means long service—unmatched freedom from corrosion.

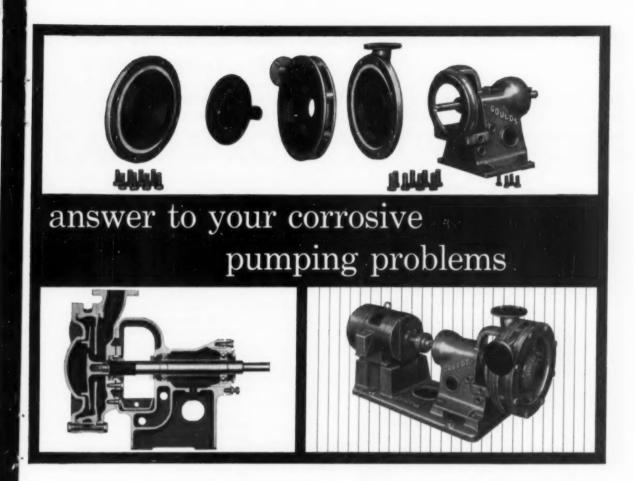
2. Elimination of stuffing box problems. The pump's unusual design places the stuffing box on the suction side of the impeller, subject to low suction pressure only. Inherently, this arrangement insures long packing or seal life and freedom

from excessive leakage.

You can get this pump with any mechanical seal arrangement to handle not only clear corrosive liquids, but also abrasive slurries. It is also available with packed stuffing box.

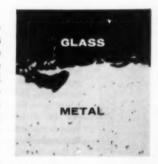
- 3. Freedom from contamination. Since the glass used in this pump is completely inert, the pumpage cannot "pick up" metallic or other substances which might contaminate or catalyze your reactions. Smoother than the most highly polished metals, the glassed surfaces of the Goulds-Pfaudler pump discourage product adhesion and scale build-up.
- 4. Mechanical strength. Goulds-Pfaudler glassed pumps are strong and durable. High temperature firings fuse the special formula glass to the metal chemically and physically, providing a permanent

Glassed Pumps



glass-to-metal bond.

The resulting combination withstands sudden temperature changes within a range of 100° F. differential—and has the durability you expect from a conventional metal pump—plus remarkable resistance to corrosion.



5. Simple centrifugal design. The glassed pump is conventional in its hydraulic design. There are no special problems of specification, installation, or maintenance. The casing design allows internal inspection, impeller and mechanical seal removal without disturbing piping connections.

**6. Economy.** The comparatively low cost of glass and the economy of the Goulds-Pfaudler production method combine to make these pumps less expensive than others using special materials and methods to achieve any reasonable measure of resistance to corrosion.

The first cost of a Goulds-Pfaudler glassed pump is likely to be less than you expect. The total cost—considering improved pumping efficiency, longer pump life, and uncontaminated process—is almost certain to be lower than any you have known in the past.

Size...capacity...head. You can choose from four different sizes of the Goulds-Pfaudler glassed pumps, and get capacities up to 700 GPM...heads up to 140 ft. The pumps are available for export.

Use the coupon for a bulletin containing complete information, including performance curves.

GOULDS PUMPS, INC., Seneca Falls, N. Y.

Please send me Bulletin 725.2 on the new Goulds-Pfaudler Glassed Pump.



Vame	Title
Company	
\ddress	
City	Zone State

#### Low Temperature Evaporation Plus Energy Economy

Indirect heat pump evaporators extend heat pump technique to lower temperatures. Handling of heat-sensitive materials, concentration of monomer solutions without polymerization, many other industrial applications are indicated or already in use.

Joseph A. Cross\*

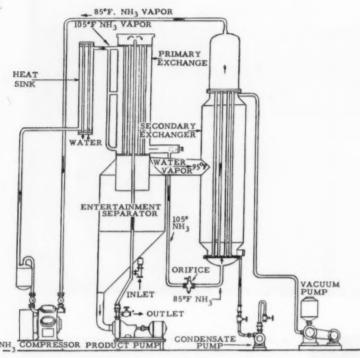


Figure 1. Indirect Heat Pump Evaporator

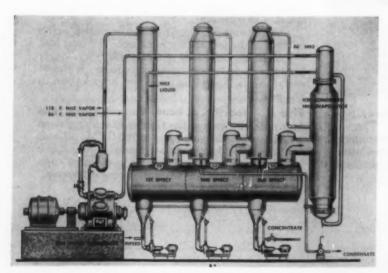


Figure 2. Triple Effect Indirect Heat Pump Evaporator

Practical application of direct heat pump distillation has generally been limited to processes in which a distillation temperature of about 212°F is not objectionable. Water vapor has a high specific volume, and this volume increases in a geometric ratio as the temperature is lowered. At 212°F, the volume is about 27 cu.ft./lb. At 177° this is doubled, at 158° it is tripled, at 142° quadrupled, and at 110° the volume is ten times the volume at 212°. The capacity of the vapor compressor must be increased in proportion to the specific volume of the vapor, and at moderately low vapor temperatures, the economy of the direct vapor compression system becomes questionable.

In the indirect heat pump evaporator, the handicap of high vapor volume at low temperatures is minimized by transferring the latent heat from high volume product vapor to low volume secondary vapor, then compressing the secondary vapor to provide the heat head necessary for evaporation

Figure 1 shows the essential elements of an indirect heat pump evaporation system. The product to be concentrated boils inside the tubes of a primary heat exchanger. The product vapor passes through an entrainment separator to a secondary heat exchanger. In the secondary exchanger, latent heat flows from the product vapor to a secondary fluid such as anhydrous ammonia, which is boiling inside the tubes. The secondary vapor is then raised in temperature by compression, enters the shell of the primary heat exchanger, and supplies the latent heat to vaporize the product.

For example, milk at a reduced pressure may boil at 95°F inside the tubes. The water vapor passes through the entrainment separator and enters the shell of the secondary exchanger where it is condensed by transfer of its latent heat to NH<sub>3</sub> which is boiling at 85° inside the tubes. This 85° NH<sub>3</sub> vapor is then compressed to 105° continued on page 134

<sup>&</sup>lt;sup>o</sup> Cross is associated with Mojonnier Bros. Co., Chicago, Ill., manufacturers of low-temperature evaporation equipment.

#### HOW THE WYSSMONT CLOSED CIRCUIT DRYING SYSTEM

## with Solvent Recovery

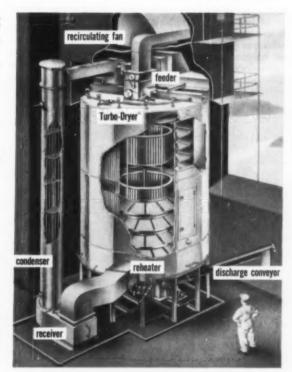
## CAN IMPROVE YOUR PROCESS

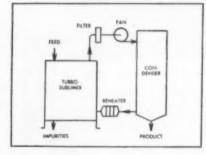
An increasing number of plants are discovering that the use of solvent instead of water, in a process which terminates with drying of a solid product, can result in these important advantages:

- Improved quality of product because low boiling solvent permits lower drying temperature
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- Operation at atmospheric pressure
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from page 132

and enters the primary exchanger. Heat flows from the NH<sub>3</sub>, condensing at 105°, to the milk boiling at 95°. The liquid NH<sub>3</sub> passes through an orifice where it is cooled to 85° by partial evaporation, and enters the tubes of the secondary exchanger at 85°, completing the cycle.

Since evaporation and condensation occur at less than atmospheric pressure, an air removal system such as a vacuum pump must be used to remove noncondensible gases. At the low temperatures and low heat heads used in this process, it is usually impossible to obtain thermosyphon circulation, and a product pump is required to recirculate the product. While the balance of heat in evaporation and condensation is equal, some heat is added to the system by compression, and a heat sink must be provided. This heat sink, usually a small shell and tube condenser, becomes the control system, a flow of water through the heat sink being modulated by the high-side pressure of the NH<sub>3</sub>.

The purpose of the double transfer of heat is to reduce the volume of vapor to be compressed. In the above example, water vapor at a temperature of 95°F has a volume of 404 cu. ft./lb. with a latent heat of 1,039 B.t.u./lb. When this latent heat is transferred to NH<sub>2</sub>, boiling at 85°F, the resulting ammonia vapor has 493.6 B.t.u. of latent heat per pound, with a specific volume of 1.8 cu.ft. The net result of the transfer is, therefore, 2.1 lb. of NH<sub>3</sub> vapor, with a volume of 3.78 cu. ft. In this transfer, the volume of vapor to be compressed has been reduced from 404 cu. ft. to 3.78 cu. ft., or over 100 to 1.

#### Multiple Effect Applications

When indirect heat pump evaporation is used, a minimum of two latent heat exchangers is required: the first to vaporize the product, the second to transfer the latent heat from the product vapor to a secondary vapor for compression. Two heat heads are also required: the first between the compressed secondary vapor and the product, the second between the product vapor and the secondary vapor. If equal heat heads are used, and equal heat transfer coefficients are assumed, then a single effect indirect heat pump evaporator would require twice as much exchange surface, and twice as much power as a direct heat pump system.

However, most large-capacity indirect heat pump evaporators are designed for multiple effect operation. That is, the first effect is heated by the compressed secondary vapor; the first effect then supplies heat for the second effect, etc. Only the latent heat of the vapor from the final effect is transferred to the secondary vapor, and this vapor is then compressed to a temperature above the boiling temperature of the first effect. Multiple effect design reduces the overall exchange surface requirements and, by a more efficient conversion of compression energy into heat head, the economy of the indirect heat pump system may equal or exceed that of the direct heat pump system.

Figure 2 shows the approximate design of a triple effect heat pump evaporator, designed to operate with an average temperature difference of 8° between the various vessels. The temperature in each vessel will average as tollows:

118° High side NH<sub>3</sub> temperature

8° MTD for 1st effect evaporation 110° 1st effect evaporation temp.

8° MTD for 2nd effect evaporation 102° 2nd effect evaporation temp.

8° MTD for 3rd effect evaporation

94° 3rd effect evaporation temp.

8° MTD for final exchanger

86° Low side NH<sub>3</sub> exchanger
In the above example, the NH<sub>3</sub> vapor will be compressed from 86° to 118°. Each 1,000 lb. of total evaporation will require the condensation of 333 lb. of vapor in the final condenser. The condensation of this vapor will require the vaporization of 708 lb. of NH<sub>3</sub> at 86°F. Compression of

this NH<sub>a</sub> vapor to 118° will require 8.45 isentropic horsepower, or 10 brake horsepower per 1,000 lb. of evaporation. 10 brake horsepower, equivalent to 25,460 B.t.u. of compression energy, actuates the distillation of 1,000 lb. of water, which requires the flow of 1,000,000 B.t.u. from condensing vapor to evaporating fluid, a ratio of 40.88 B.t.u. of energy cycled to each B.t.u. of energy used.

#### News briefs

Continued weakness in the textile and industrial yarn markets has forced the Chemstrand Corp. to temporarily curtail production and lay-off over 500 employees in its Pensacola, Fla., nylon plant.

Two new polyvinyl acetate emulsions will be made in a new unit to be constructed at the Toledo, Ohio, plant of DuPont's Electrochemicals Department. The new products are water-resistant, extremely small particle-size emulsions designed primarily for use in water-base paints; they are designated "Elvacet" 1423, which may be used without adding a plasticizing agent; and "Elvacet" 1440, which requires the addition of a plasticizer to achieve flexibility.

A polyethylene plant of 75-million pound capacity a year will go into construction soon at Houston, Tex. for National Distillers and Chemical Corp. Completion is scheduled for early in 1959. #

Going directly into the naval stores business for the first time, Monsanto Chemical has purchased the physical assets of Filtered Rosin Products, Inc., Baxley, Ga. Filtered Rosin, a producer of paper size and other gum rosin products, turpentine, and tall oil rosin, will become a division of Monsanto under the name Filtered Rosin Products Company.

New facilities for the production of high-grade barium monohydrate will go into operation this fall at Sherwin-Williams' Coffeyville, Kan., plant site. In the plant which is now under construction, a new process will produce the barium monohydrate directly from barytes ore. The product will have at least 99 percent purity, will be marketed at the going price of barium oxide on an available barium basis. The Bunker Hill Co. of San Francisco, major producer of zinc and lead metals, has a 25 percent participation in the new installation. #

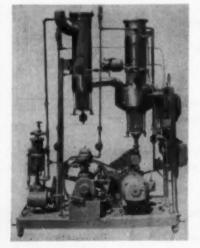
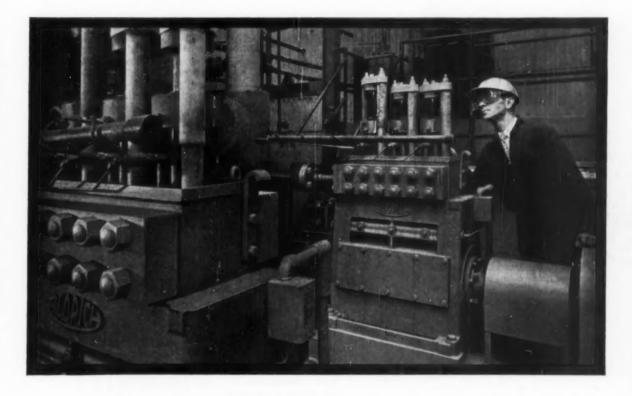


Figure 3. Standard Mojonnier Pilot Plant Model

SPENCER CHEMICAL CO. UNRAVELS KNOTTY PROBLEM:

## Maintaining a controlled flow of liquid ammonia at high pressures, 24 hours a day.

At the Vicksburg, Miss. plant of Spencer Chemical Company, ammonia production demands two things of pumps: (1) 24-hour, 7-day-week operation and (2) continuous flow of controlled volumes of tiquid ammonia at high pressure.



How Spencer licked the problem: When Spencer began outlining construction plans in 1951, company engineers specified two Aldrich Direct Flow, 3/1" x 3" stroke Triplex Pumps. These were scheduled to be used for alternate 30-day periods. According to company spokesmen, nearly four years of service have proved these pumps to be efficient and capable of durable service.

Results: Dependability and freedom from

trouble in all phases of operation. The Vicksburg Works Maintenance Superintendent tells us: "The Aldrich Pump is an excellent unit. Valve life is excellent and packing life exceptionally good."

We'll be glad to send you full information on Aldrich Pumps and their advantages to you. Simply write Aldrich Pump Company, 20 Gordon Street, Allentown, Pa.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

#### news briefs

Two of the four chemical processing areas under construction at Callery Chemical's new Lawrence, Kan., plant went into operation April 1. Both processing areas will produce intermediate chemicals used in the manufacture of HiCal liquid boron-based fuel. The company expects to be producing HiCal within several months, but the facilities at Lawrence will be switched over to production of boron specialty chemicals for commercial and industrial use as soon as the company's Muskogee, Okla., plant goes on stream in December, 1958. #

The U.S. Court of Appeals for the Fourth Circuit has unanimously ruled for Merck & Co. in its action against Olin Mathieson for patent infringement. This was a reversal of the District Court decision in the case involving vitamin B<sub>12</sub> concentrates. The Appeals Court has now remanded the case to the District Court to rule on the question of infringement since all that had been previously considered was the validity of Merck's patents. #

Volume production of allyl alcohol has started at Dow Chemical's Texas Division. Since it contains both a double bond and a primary hydroxyl group, allyl alcohol will react both as an olefin and as a primary alcohol. As produced by Dow, it will have a minimum assay of 98 percent. Allyl alcohol is associated with Dow's synthetic glycerine process. Another product associated with the glycerine process, allyl chloride, will be produced by Dow starting in June or July. #

Engineering design contracts for another expansion of Texas Eastman's polyethylene plant at Longview, Tex., have been given to the Girdler Construction Division of National Cylimder Gas Co. The contract includes engineering and procurement of equipment and materials for the expansion which will increase the Longview plant's capacity to 85 million pounds of polyethylene a year by the end of 1958. The increase in capacity will include both conventional low-density polyethylene and a new medium-density product.



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- \* Costs reduced on installation and maintenance.
- \* Steam and electric heaters eliminated . . . reducing utility costs.
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- \* Explosion proofing eliminated.



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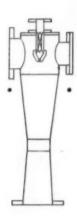




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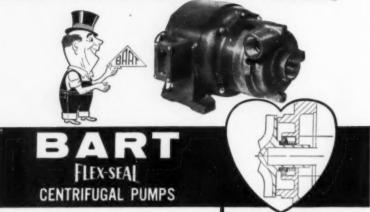


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No longer need you cut down bigger pumps in range and lose efficiency—or put up with undependable smaller pumps.

Bart pumps have fewer parts to wear or get out of order. Six models, each in corrosion resistant Type 20 Stainless Steel. Or other alloys on special order.

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Effectively minimizes a long-prevalent basic weakness of centrifugal pump design. Self-adjusting to wear. Needs no external lubrication. Carbon stator/ceramic seat, unexcelled for long wear—or zircon filled Teflon/work-hardened Type 20 Stainless Steel, for severest corrosive service.

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With free air the cooling medium you use the least water, evaporated in the air stream. You save the cost and pumping of large volumes of condensing water.

Air-vapor subcooling reduces mixture evacuated from the system, saving in the operation of steam ejector or vacuum pump.

This air-cooled condenser gives you more capacity than other types at a substantial saving of steam and power. Water supply, scaling treatment and disposal problems are eliminated.

You get pure condensate, an improved product; often make a profit on recovery of residues now wasted. There can be no contamination of your product at any time; it never touches raw water. Condensing, of water, of solvents or of your product, is simplified; you have one, compact,



Niagara Aero Vapor Condenser. This compact machine may be installed directly above stripping column or vacuum evaporator.

easily maintained unit replacing both cooling tower and barometric or surface type condenser.

Maintenance expense is low. Balanced Wet Bulb Control provide precise, year 'round adjustment of capacity to load.

Constant temperature, uniform products and maximum production 12 months a year are assured. Unit capacities up to 15 million BTU.

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#### NIAGARA BLOWER COMPANY

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Niagara District Engineers in Principal Cities of U. S. and Canada

A long term agreement for the production of alkylate has been concluded between Petro-Tex Chemical of Houston, Texas, and Plymouth Oil of Pittsburgh, Pa. A 3,000 bbl./day sulfuric acid alkylation plant is under construction by Petro-Tex at Houston. Part of this capacity will be used to produce alkylate for Plymouth Oil from feed supplied by Plymouth. Petro-Tex will also produce alkylate from butylenes from its butane dehydrogenation plant.

Conversion of a hydroformer into a UOP platforming unit has been completed at Texaco's Lockport, Ill. refinery, and the unit is now on stream. A unifining unit, set up in combination with the Platformer at Lockport, serves as a pre-treater. Design of the combination unit is 9,000 bbls./day.

Commercial output of 98% ethylene diamine is now underway at the Organic Chemicals Division of Olin Mathieson Chemical. According to Mathieson, 85-88 and 90-93% ethylene diamine will continue to be produced, and there will be no change in the availability of polyamines 333 and 910.

A major facility for development and production of solid propellants for long-range rockets and missiles will be built at Hercules' Bacchus, Utah Plant. #

A new sales development section has been established by Du Pont's Explosives Department. Purpose is to provide technical service to customers, and to develop sales for the department's chemical and specialty products. The department has been carrying on an intensive diversification program in chemical products which include cellulose derivatives, nitrogen compounds, and polymer intermediates.

New dense soda ash facilities at Solvay Process Division's (Allied) Baton Rouge, La., plant will more than double previous capacity. #

High Voltage Engineering Corp. has acquired controlling interest in Electronized Chemicals Corp., N. Y. Electronized Chemicals has been a pioneer in electron processing research for more than ten years. Pooling patents and experience with its new acquisition is expected to materially strengthen High Voltage's position in the development and production of powerful radiation machines for the processing of chemical materials. #

## BUTADIENE CAPACITY INCREASED 365,000 Tons/yr in 1957

85% THRU ISOFLOW HEATERS

... and "Isoflows" in five new Butadiene plants are additionally supplying 1,000,000 lbs/hr of superheated steam up to 1400° F

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Isoflow Furnaces efficiently perform two important heating functions, depending upon the butadiene process inve (A) To heat directly the butane-butene feed stock and steam to a high temperature for dehydrogenation.

(B) To supply highly superheated steam which in turn heats the butane-butene stock for dehydrogenation.

The unique design and operating features which have led to the wide acceptance of Petrochem Isoflow Furnaces include:

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- · Low Pressure Drop
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- Minimum Ground Space
- Simplicity of Design and Construction
- Short Length of tiquid Travel
   Series, Multipers, all perallel fil
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e butadiene production, catalytic reforming or any other petroleum, petrochemical or chemical process there's a Petrochem Isoflow Furnace for any duty, temperature and efficiency.

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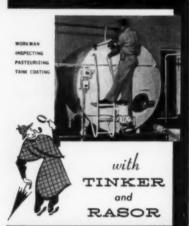
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#### news briefs

Du Pont bought \$860 million worth of materials and services last year from more than 30,000 different suppliers—emphasizing the company's dependence on small business firms. Most of this, over \$710 million was spent for a wide variety of chemicals, supplies, and basic materials.

Insular Chemical Corp., Hicksville, N. Y., is now a wholly-owned subsidiary of Rubber Corp. of America. Rubber Corp. acquired the entire interest of Pollak Industrial Corp. to obtain the polyvinyl chloride resin manufacturer.

Consolidation of two of its west coast Dicalite diatomite plants has been announced by Great Lakes Carbon Corp. The company's Walteria, Calif., plant has been closed and all its facilities moved to the plant at Lompoc, Calif. An increase of 70 per cent in the productive capacity of the Lompoc plant is expected to result. Overall production will remain the same.

A \$10.3 million portion of the contract work on Callery Chemical's boron high energy fuel plant at Muskogee, Okla., has been awarded to Macco Corp. in association with H. K. Ferguson Co.

A price decrease of four cents a pound is now effective in the base price of general molding and extrusion grades of W. R. Grace's high density polyethylene. The reduction, from 47 cents to 43 cents a pound, is based on the rapid progress of market development for the Grace Polymer Division's new material.

Just two weeks and three days after fire destroyed American Air Filter Co.'s Plant No. 2, the firm shipped its first orders from a relocated site.

Acetyl peroxide will be manufactured by Wallace & Tiernan, Lucidol Division, under exclusive license from Becco Chemical Division, Food Machinery and Chemical, under the terms of a recent agreement.

Latest entry into the field of filtration equipment for the chemical industry is Read Standard Division of Capitol Products Corp. The firm says it is now perfecting prototypes of industrial filters based on entirely new concepts in filtration theory.



Here's a really fast-and easy-way to make accurate colorimetric tests for pH, chlorine, phosphates, nitrates, etc. Lightweight, portable Taylor Comparators give you dependable, on-the-spot operational data in minutes . . . not hours! Help you control crystallization, bleaching, precipitation, extraction or waste treatment faster. Tests are made simply by placing the treated sample in the middle tube and moving the color standard slide across until the sample matches one of the standards. Values are then read directly from the slide.

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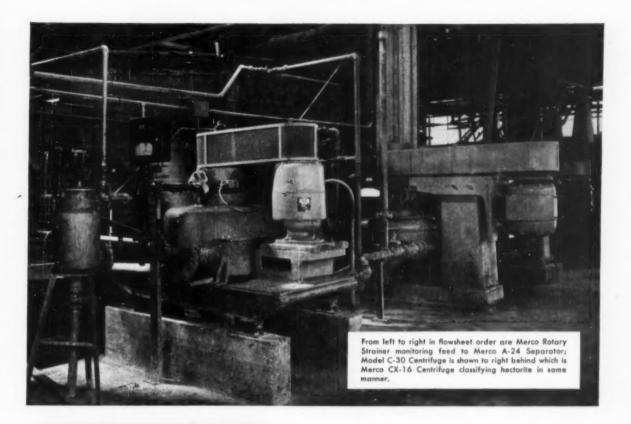
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Merco Centrifugal Classification of Micron Size **Particles** 

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For more details on the complete line of Merco Strainers, Centrifuges and Screening Centrifuges, just drop a line to Dorr-Oliver Incorporated, Stamford, Connecticut.



#### Nuclear Reactor Feed-Materials Plant

Production of nuclear reactor feed materials is underway at a new plant of Davison Chemical Co. Division of W. R. Grace at Erwin, Tenn.

Built at a cost of \$2 million, the new Davison plant is an important step forward in the practical development of nuclear power by private capital. It fills an essential intermediate position between primary producers of thorium and uranium raw materials, and the ultimate industrial users of nuclear materials in reactors.

The Davison plant operation is broad enough to require three different processing buildings—a metals building, a chemical process building, and a ceramics building. With its present equipment, Davison feels that the new plant can perform nearly all feed material functions, claims the plant is the first completely integrated plant of its type constructed by private industry.

Essentially, the plant takes thorium or uranium concentrates from industrial sources, or enriched uranium hexafluoride from AEC gaseous diffusion plants, and converts these source materials to thorium oxides, nitrate, metal or alloys; uranium oxides, tetrafluoride, metal, alloys and other components.

Davison claims two important distinctions for its plant:

The only facility in private industry where the pulse-type solvent extraction process developed by AEC is used for purification of uranium and thorium.

The only completely integrated facility for producing uranium and thorium oxide powder, compacting and heat treating them, assembling them into finished fuel elements, and recovering scrap. (A job of this type is now in progress at the plant.)

Two main process streams

There are two main manufacturing processes at the plant depending on whether uranium or thorium is the element concerned.

The uranium process can itself follow two paths. In the first method, uranium hexafluoride is converted to uranium tetrafluoride by reaction under heat with hydrogen. This is reacted with steam to produce uranium dioxide, or reacted with calcium or magnesium to produce uranium metal. The metal is melted in vacuum

to produce ingots which are either pure or alloyed. The metal can then be rolled or extruded into whatever form is desired.

In the second uranium method, the uranium hexafluoride gas is dissolved in water or reacted with steam, producing uranyl fluoride in solution or powder form. Alternatively, the gas can be reacted with ammonia to yield ammonium diuranate, which can be decomposed with heat to produce uranium oxide, which in turn can be heated in hydrogen and converted to uranium dioxide.

In the thorium process, thorium concentrate is digested in acid and the thorium is solvent extracted in pulse columns. Thorium is then precipitated with ammonium hydroxide or oxalic acid. Under heat this is decomposed to thorium oxide which is shipped as such or reacted with calcium to provide thorium metal. Or, the thorium oxide can be sintered into dense compacts, after being blended with uranium oxide, and the compacts can be loaded into tubes as reactor fuel elements.

Non-nuclear applications

Although the primary design of the new Davison plant is for nuclear applications, it is also equipped and staffed to produce metallic materials for non-nuclear use. Among such ma-



A bird cage type of crate is loaded with stainless steel rods containing uranium oxide-thorium oxide pellets for reactors' use, at Davison Chemical's new reactor feed materials plant.

terials now available are thorium metal, a master alloy of thorium and magnesium, and ingots of finished alloy for processing to structural or cast components. At present these products are in demand for aircraft components, refractories, and in the electronics field.

Thorium oxide is one of the highest melting compounds known (6522°F), and is being used for ultra high temperature refractories.

Uranium-238, the non-fissionable by-product after U-235 separation, gives excellent shielding against radiation.

#### New Gallium Recovery Process

A process which Dow expects will make possible the extraction of "substantial" quantities of the relatively rare metallic element gallium has been developed and patented (U.S. Patent No. 2,823,096) by two of Dow's research scientists, L. K. Frevel and J. T. Kummer. The element occurs widely in nature, but in very small amounts, and is most remarkable for its low melting point—29.7°C. Major present source is aluminum ore.

The new process consists of treating sub-divided ore containing the metallic element with a current of hydrogen chloride or hydrogen bromide under substantially anhydrous conditions at a temperature ranging from 700°C. to 950°C. The hydrogen chloride or bromide current is passed over the ore in sufficient quantity to volatilize the gallium as the trihalide. It is then condensed and recovered as the pure material.

At present, the commercial potential of gallium is undeveloped. But considerable work has been done on possible uses for the element in the growing electronics field, and it has potential use as an amalgamating agent in place of mercury.

Dow has no immediate plans for producing gallium but the new process is available should demand for it grow.



#### Whither Lithium?

The question is 'how to consume enough?'

There are abundant supplies of lithium but too little inclination to exploit them. There are a host of promising uses for lithium but a decline of interest in either applying them or finding more. Why the contradiction?

An unusual chain of circumstances has probably been the chief contributing factor to the present uncertainty. Unavoidable secrecy surrounding some of the uses of lithium in the nuclear field and in other strategic areas has led to classification of production statistics in the United States. The AEC did reveal in 1957, however, that it was purchasing lithium hydroxide, extracting the lithium-6 isotope, and stockpiling lithium hydroxide enriched in lithium-7. Suppliers of the original material have the right to repurchase the stockpiled lithium hydroxide under the terms of contracts with the AEC-exact percentages available for repurchase have not been revealed, nor, of course, the extent of the stockpile.

Since lithium-7 comprises about 92.5% of naturally-occurring lithium, most of the lithium sold to the AEC ends up in the stockpile. Evidently, the existence of such a reservoir of available lithium, coupled with the present productive capacity of the three or four main American producers,\* is acting as a brake on further rapid expansion of mining operations or refining facilities.

Several potential developments may, on the other hand, reverse the present trend. Most exciting development is in the field of high energy fuels. While details are not available, an educated guess is that the Olin-Mathieson plant now under construction at Model City, N. Y. will react lithium hydroxide with boron trifluoride etherate to yield diborane. (On the other hand, reports are that Callery Chemical, the other major American high

energy fuel producer-to-be, has settled on a sodium-based process.)

Dispersons of lithium metal in hydrocarbons act as an efficient catalyst for the polymerization of isoprene into a cis-polymer said to be a true synthetic counterpart of natural rubber. This discovery was the work of researchers at Firestone Tire and Rubber in Akron: patents have been granted in several countries with many more applications pending. Unfortu-nately, however, this use holds no promise of providing a mass market for lithium since the amount of catalyst required is almost microscopic. Another catalyst use may be in modified Ziegler-type catalysts which would make use of the definite stereospecific catalytic action exhibited by certain lithium compounds.

High specific heat, large liquid range, high thermal conductivity, low viscosity, and low density-all this adds up to a desirable combination of qualities for a heat transfer medium. Present fly in the ointment is that lithium can be extremely corrosive if

not highly purified; main harmful contaminants are oxygen and nitrogen. Exploitation of lithium's low density for use in aircraft and missile coolant systems must therefore wait on a more complete solution of the purification process, a solution which must include development of new and more sensitive analytical techniques for minor impurities.

For nuclear applications, there is a second consideration. The lithium-7 isotope has a much lower neutron absorption cross section than natural lithium or than the other isotope, lithium-6. Isotope separation is a must for heat transfer applications in this

Experts in the field believe that the desired market for large scale lithium production may well lie in the fabrication of special alloys. Work by Dow Chemical, the U.S. Bureau of Mines, and others, has concentrated on magnesium alloys containing more than 10% lithium. Reasons for the high lithium percentage-at this figure, a phase continued on page 146

#### Neoprene Cure Continuous in Liquid Bath

DuPont offers know-how to molders and extruders

In a move to step up the market potentialities of neoprenes (and other elastomers), DuPont is making available license rights to a new curing process developed at their Chestnut Run, Delaware, Elastomers Laboratory. The method: continuous curing in a liquid curing medium at temperatures from 400 to 600°F., curing times of less than 30 seconds.

Either molten metals or certain high flash point oils can be used as the heat transfer medium: both types of me-dium have advantages, but molten metals are generally preferred. Molten metals can be used at higher temperatures which permits faster cures. Use of a precoating of talc or oil prevents the metal from clinging to the extrusion surface; thus, there is no bath loss and little need for cleaning the extrusion. Biggest disadvantage of molten metal is high density which tends to distort certain types of extrusions-particularly hollow cross sections with thin walls. In such cases distortion is avoided by use of a low density heat transfer medium, such as a high flash point oil; this, however, means lower curing temperatures than

with metals and demands a slower extrusion rate or a longer curing tank.

A large number of low-melting alloys can be used. One which has been used successfully at DuPont is Asarcolo 281, a eutectic mixture of 42% tin and 58% bismuth, available commercially from American Smelting and Refining. A low-cost parafinnic type petroleum oil can be used with neoprene extrusions. Silicones are satisfactory but expensive, would probably have to be reclaimed from the cleaning bath to be economical.

Vacuum extrusion licks porosity.

Chief stumbling block in the development of a continuous curing process has been the problem of porosity in solid extrusions. While neoprene can be handled in standard extruders by proper mixtures of stock, addition of reinforcing types of fillers, etc., the best method, according to DuPont engineers, is vacuum extrusion. This type of equipment will, they say, extend the use of the new liquid curing medium process to include conventional compounds as low as 40 du-

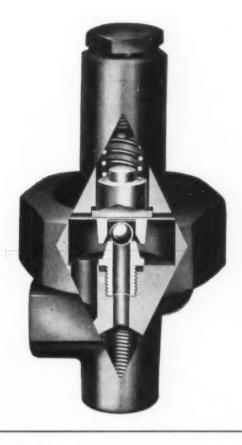
continued on page 146

<sup>•</sup> U. S. Lithium Producers:

American Potash & Chemical Corp., Trona, Calif.

Foote Mineral Co., Sunbright, Vir-

Lithium Corp. of America, Bessemer City, North Carolina. Maywood Chemical Works, Maywood,





#### Take a second look

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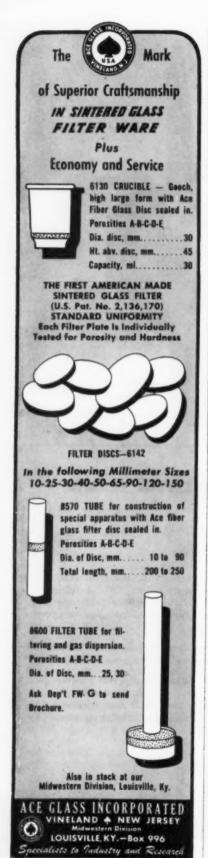
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#### Whither Lithium?

from page 144

change converts the magnesium to a cubic crystal structure; the alloy reputedly has the highest strength-toweight of any known alloy, in addition to good working properties. Difficulty here is brittleness on aging. Research is continuing.

Beryllium-lithium alloys should also have interesting properties. However, as far as is known, no reliable data is available and no intensive research program has been initiated.

Against a background of oversupply and threatening stockpiles in the U. S., Montgary Explorations, Ltd. is busy in Manitoba, Canada, developing what they claim is the highest grade lithium deposit in the world. Extensive exploration and preliminary mining operations are well advanced, and it is believed that plans include erection of processing facilities.

#### Neoprene

from page 144

rometer, non-black compounds, and very highly extended compounds. A vacuum screw type extruder has been designed and patented by DuPont, but it is understood that licenses for its use may be obtained free by any manufacturer of machinery who desires to make such equipment.

Claim many advantages

In addition to obvious cost savings from reduced handling and labor charges, the method is said to offer other important advantages including: lower capital investment compared to conventional steam vulcanizing, less floor space requirement, and less scrap waste.

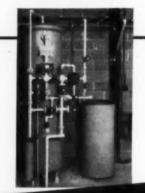
Unaudited net earnings of Monsanto Chemical were 6.8 percent higher in 1957 than in 1956. Total sales for the company, its domestic and foreign subsidiaries, and that portion of the sales of associated companies represented by Monsanto's 50 percent ownership, amounted to \$708,005,000. This was an unaudited net earning of \$48,878,000.

Chas. Pfizer & Co. has been named industrial advertising's "Company of the Year" by Industrial Marketing magazine. Cited for its distinctive annual report, and corporate and divisional advertising programs, the chemical and pharmaceutical firm was described as a company which has developed "a wonderful creative atmosphere which leads to distinguished advertising."

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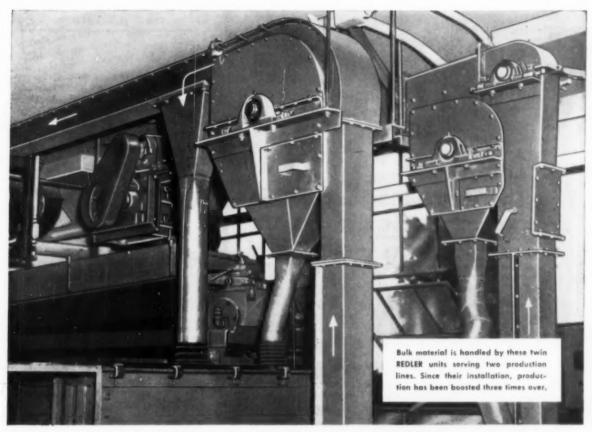
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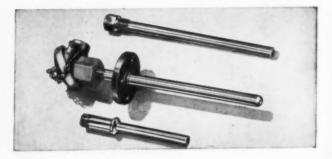
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A multi-purpose ore tanker, the first of its kind to carry bulk solids in slurried, pumpable form, is being planned to ferry nickel and cobalt concentrates from Moa Bay, Cuba, to Freeport Sulphur's Port Nickel, La. refinery. The tanker will carry molten sulfur and liquid petroleum gas (required for processing the ores and neither of which is available in Cuba) to Cuba, and return with the nickel and cobalt concentrates properly mixed in slurry form for loading and unloading by pipeline.

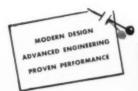
To maintain the sulfur above its 240°F. melting point in transit, the ship tanks will be insulated and heated. It will take five months to convert the vessel to its new use.

Production from the Cuban American Nickel Co. subsidiary of Freeport Sulphur at Moa Bay is expected to start the middle of 1959. The annual output of 50 million pounds of nickel and 4.4 million pounds of cobalt will make Cuba the world's second largest nickel source and the largest cobalt source in the Western hemisphere. The \$119 million project will increase the U. S. supply of strategic nickel by some 15 to 20 per cent.

A Chemical Propulsion Division has been formed in the Explosives Dept. of Hercules Powder Co. The new Division will be concerned with design, development, production, and sales of propulsion units for applications ranging from missiles and space vehicles to small, compact, packaged power units. It will also handle the smokeless powder operations of Hercules.



This is the new \$40 million building of Convair (Astronautics) Division of General Dynamics Corp. The building is now housing the company's pilot production of Atlas ICBMs. Convair has invested about \$20 million in the new plant, the Air Force is installing \$20 million worth of equipment.

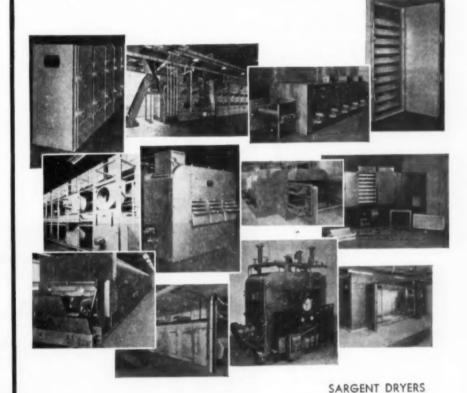


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#### Congress Delays Translation Funds

House and Senate finance committees have not taken action to authorize a requested \$300,000 supplemental appropriation intended to implement immediately the technical translation program slated to be run by the proposed Foreign Technical Information Center, under the Department of Commerce. (See CEP Scope, Feb. '58). Included in the program is Russian translations.

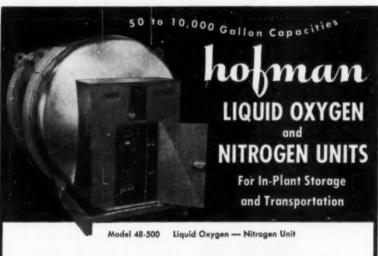
As matters stand, activation of the new Center will probably wait until action is taken on the President's 1959 budget sometime after the Easter Congressional recess. The \$1,250,000 earmarked for this purpose in the budget will thus probably not be available until the start of the new fiscal year on July 1.

Of the \$1,250,000 appropriation, \$900,000 will serve to set up a central clearinghouse for collection, evaluation, and distribution of foreign technical literature; \$300,000 will go to support translation activities in the industrial technology field. According to

John C. Green, who will head up the program, initial emphasis will be heavily on translation of technical articles from Russia and the Satellite Countries: in the future, other languages, in particular Chinese and Japanese, will undoubtedly demand an increasing share of attention.

Market research activities of Diamond Alkali's Commercial Development Department are being expanded to provide increased research on existing products. Previously, the Market Research Section of Diamond's Commercial Development Dept. was concerned primarily with market research dealing with new products. The broader assignment taking in existing products necessitated the enlargement.

Construction has begun on an industrial cleaning compound and detergent plant for the Du Bois Co., Inc., of Cincinnati, Ohio, in the East Rutherford Industrial Park, East Rutherford, N.J. The new plant will absorb and consolidate older Du Bois plants in Newark, N.J. and Brooklyn, N.Y. #



These low-loss storage and transport units are skid, caster, wheel and trailer mounted and are available in capacities to 3500 gallons. Larger vessels for bulk liquid storage are sized to 10,000 gallon capacities. All units feature standard equipment as follows: bottom fill and discharge line, top fill line,

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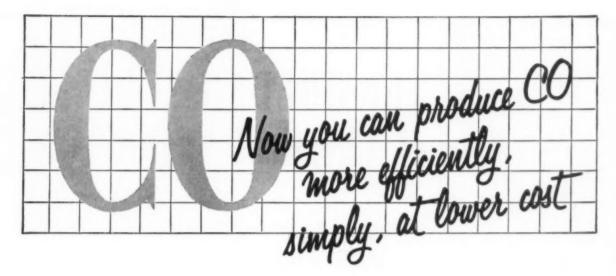
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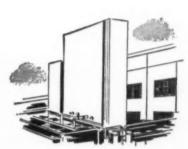
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#### Jubilee Town

Philadelphia, a.i.ch.e.'s birthplace and host city for the Golden Jubilee meeting, has played an important part in American life, from its days as William Penn's "Greene Countrie Towne" to the mid-twentieth century. The nation's oldest metropolis, Philadelphia is particularly rich in history. Today, the city holds an outstanding place in the contemporary scene as a result of unprecedented development in the area of the Delaware River basin, of which Philadelphia is the economic, cultural,

and geographical center.

The Delaware Valley is a major industrial center on the American scene. The Port of Philadelphia ranks at the top of the list, and the area is the fifth largest manufacturing center in the United States. The Philadelphia community is also a center of cultural activities. Many of these are allied with the thirty-one colleges that make the area one of the Nation's leading educational sites. By no means least, Philadelphia offers a wide choice of entertainment in eating places, sporting events, concerts, and theatres. Following its development in the early years of the eighteenth century, Philadelphia became the leading shipping and commercial center of the Colonies, and, with the signing of the Declaration of Independence, the Cradle of Liberty. Independence Hall, where the Declaration and the Constitution were signed, has been called America's most famous landmark. Here also, in Independence Square, is Congress Hall, where the Congress of the United States met during Philadelphia's days as Federal Capital, from 1790 to 1800. The first Supreme Court of the United States convened in Old City Hall, nearby. Two blocks down Chestnut Street, at Carpenters' Hall, is the meeting place of the First Continental Congress (1774), and close by at the home of Betsy Ross is the birthplace of the Stars and Stripes.

Philadelphia has an impressive list of "firsts" and "oldests". Near Carpenters' Hall stands America's oldest banking building, built in 1795. Philadelphia is the site of the first U. S. Mint. The Pennsylvania Hospital, founded in 1751 and built "well out in the woods" was

the first hospital in the U.S.

Within 100 miles of Philadelphia is the United States' largest concentration of population (13.8%) and business firms (16.2%). The Port of Philadelphia ranks number one in the country in terms of total tonnage and imports. That there is an abundance of industry, and that this industry is new, big, and still growing, is attested by the fact that 87 corporations and government agencies have planned for new capital investment between 1950

and 1960 to the extent of nearly four billion dollars. The Chemical Industry and its major ally, Petroleum Refining, are prominent among the industries that are responsible for the area's booming growth. They rank second only to the metals industry in terms of capital invested and value of products. A list of the companies operating major installations in the Philadelphia area includes du Pont, Rohm and Hass, Barrett Division, and American Viscose among the Chemical producers, and Atlantic Refining, Sun Oil, Gulf, Socony Mobil, Sinclair, and Tidewater in petroleum refining. The latter's new \$193-million refinery at Delaware City, Delaware is one of the most modern and extensive in the world. Attendance at the Golden Jubilee meeting will give visitors an opportunity to tour these plants.

Philadelphia's leading place in the American arts is secure, too. The printing and publishing business is one of the region's largest, and has been since the days of Benjamin Franklin. The city's free library has over 1½-million volumes, and the main building is one of the world's largest. Outstanding collections are housed in the Museum of Art, well worth a visit for the impressive building alone. The Philadelphia Orchestra is one of the world's leading symphonic organizations, and although the regular season will have ended by June, visitors will have an opportunity to hear the orchestra in outdoor concerts at Robin Hood Dell in Fairmount Park. In the sciences, Philadelphia offers the Academy of Natural Sciences, Franklin Institute, and the Fels Planetarium—all worth at least one visit.

Philadelphia offers a wide variety of recreational activity too: night clubs and movie theatres, the restful quiet of beautiful Fairmount Park, and a gamut of diversions between. During the week of the Golden Jubilee meeting, the Philadelphia Phillies will be playing at Connie Mack stadium, while for those who appreciate the theatre, the Playhouse-in-the-Park will be a real treat.

Among the famous dining places in Philadelphia are the old original Bookbinders, the Warwick Hotel and Shoyers. For ice cream or good sea food in quaint surroundings, try the Reading Terminal Market. Here are displayed foods from all over the world.

With all the diversified activities and interesting sights, in addition to the new and important ideas and developments in the field of chemical engineering, the Golden Jubilee meeting will be a truly broadening experience.

E. J. STREET, JR., T. R. BELL

#### Local Sections Feature Nuclear Engineering, Petrochemicals

Relating current atomic developments to the chemical process industries, R. E. Vener, Catalytic Construction Co., pinpointed the business incentives in atomic energy to the January meeting of the Rocky Mountain Section (F. H. Poettmann). The former Manhattan Project research scientist showed how much of nuclear technology depends on the unit process work of the chemical engineer, and how certain areas, such as fuel reprocessing, are the primary concern of the chemical engineer and the chemical process industries.

At the Charleston Section (L. L. Cavender) in January, the subject was again atomic energy. Specifically, A. R. Jones, Westinghouse, discussed in detail the generation of atomic power by means of pressurized water reactors. The pressurized water generator is a machine that uses water under 2000 lbs./sq. in. gauge for transfer of heat from the atomic pile to an heat exchanger for steam generation. The pile is composed of UO2 pellets sealed in stainless steel tubes. Precision is required in the manufacture of both tubes and pellets. The pile, circulating pump, and heat exchanger are all housed in a spherical, stainless steel lined, carbon steel vessel with a thick concrete outer shell. This type of construction is costly, but it is necessary for protection of the operating personnel and the surrounding communities in which a plant may be located. The steam turbine is located outside the sphere. Numerous auxiliary systems and controls are employed in the operation of the reactor.

The pressurized water reactor is a low efficiency machine and cannot compete today in this country with standard power generation systems. In Europe, however, where the cost of conventional fuels is a major factor, there is considerable potential for such current atomic power equipment as a pressurized water reactor.

Some of the problems connected with the pressurized water reactor, as well as with some other types of reactors, are:

- 1. Corrosion resulting from high temperature (650°C.), high purity water.
- Technology involved with turbines using saturated steam.
  - 3. Safety and the related costs.
  - 4. Initial cost of construction.
  - 5. Disposal of radioactive wastes.

Fully aware of the problems they face, 12 companies are pooling their resources for the development of an efficient machine, and the operation of a 134,000 KW machine has been set for 1960.

Pyroceram, heat exchange, gilsonite

Pyroceram is a crystalline form of glass which has toughness, hardness, and heat resistance which makes it suitable for many unusual purposes from frying pans to missile nose cones. With this statement, B. Allen, Corning Glass Works, opened his talk to the February meeting of the Alton-Wood River Section (J. G. Huddle). Allen outlined the progress of Corning's research from the development of filter glasses in 1908, through the discovery of methods of phase separation and leaching techniques which made possible the manufacture of Vicor pure silica glass, to the discovery of methods of controlled nucleation and crystal growth which in turn made possible the development of photo-sensitive glass and-Pyroceram. One of the major properties of Pyroceram is a coefficient of thermal expansion of essentially zero in the range of 0 to 300°C. At present, Corning has Pyroceram corrosion resistant heat exchangers and ceramic tubes for use with metal tube sheets, under development.

Continuing the heat exchange theme, the February meeting of the Detroit Section (J. E. Ohlson) heard A. R. Conant of Dow Chemical describe his company's Dowtherm, A Modern Heat Transfer Medium. A eutectic mixture of diphenyl and diphenyl oxide, Dowtherm is a high temperature, low pressure heat transfer medium. Two industries which have found Dowtherm a useful product are the vegetable oil industry and the varnish industry. In the varnish field, according to Conant, are the greatest number of Dowtherm units which have replaced direct fired systems. Conant also showed a film which

emphasized what Dow feels are the advantages of vapor phase heating.

Gasoline and coke from Gilsonite held the attention of the October meeting of the Northern California Section (J. G. Tewksbury). W. J. Rossi, California Research Corp., discussed the recently started operations of the American Gilsonite Co.'s new plant in Western Colorado which derives both coke and gasoline from Gilsonite mined in Eastern Utah by a specially developed method. Several new scientific and engineering accomplishments were made in starting this project. Gilsonite is a solid hydrocarbon and special wet methods of mining had to be developed. A unique feature of the refinery is that all products except coke and gasoline are used up in the plant, or processed to extinction. High grade gasoline components are made by treating the light part of the coker gasoline, and two-stage platforming the rest.

A Consumers Look at Textiles was shown the January Meeting of the East Tennessee Section (J. C. Umberger) by R. L. Churchill of Eastman Chemical Products, Inc. The first fact Churchill emphasized is that there are so many man-made fibers today that the consumer is often confused by them. Unfortunately, the manufacturer of the base fiber has little control over the quality of the consumer product into which the fiber goes. Yet, the fiber manufacturer is forced by law to give equal advertising aid to the makers of both good and bad consumer products which incorporate his fiber. And if the product performance is not good the fiber manufacturer will probably get the blame. To minimize this difficulty, Churchill showed that Eastman carefully picks its customers when introducing a new fiber. In this way there is at least a better chance that the consumer will get a better product and not blame Eastman's fiber.

One-day technical meetings

Any lagging interests in the technical subjects of electrochemistry, corrosion, and instrumentation were revived by occasional participation in continued on page 156

Some of the speakers at Southern Nevada's one-day meeting. In the us ual order; Spracklen. Xerstner, Koehler, Pearson (Chairman), Basilevsky, Tobias.





helps to create
HEADLINE products

## Thimet

'built in'
protection that
immunizes the cotton
plant by treating
the seed



A revolutionary idea...this treatment of the seed in order to protect the young plants against the onslaught of sucking and chewing insects that are prone to attack young plants. The immunization lasts up to seven weeks, or long enough for the plant to get a good strong start without the need of spraying or dusting. This particular

treatment is called "Systemic", a term based on the fact that the chemical used is actually introduced into the system of the plant. The seed, coated with the insecticide, is planted and as the plant grows, the protective chemical is drawn up from the seed into the sap stream, flowing to all parts of the plant.

This unique compound is called THIMET which has the following empirical formula:

C,H,,O,PS,

Note the presence of Sulphur. THIMET is one of the latest in a long line of useful agricultural formulations which either end up with Sulphur in the product itself or require Sulphur or a derivative in the processing. Because of its revolutionary impact actually upon the cotton growing industry and potentially upon other agricultural activities, THIMET can rightly be called a 'headline product'.

\*THIMET is a tradename of American Cyanamid Company.



#### Texas Gulf Sulphur Co.

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Sulphur Producing Units

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- Spindletop, Texas
- · Worland, Wyoming



à Rexall Drug Co., Subsidiary - KP-

from page 154

the mathematics of dice, black-jack and roulette, Southern Nevada's (John L. Pearson) one-day technical session in Las Vegas, January 18.

Among the main problems to be considered in scale-up from laboratory size to plant size electrolytic cell operation, C. W. Tobias, Assoc. Prof. of Chem. Engg. at Univ. of California mentioned: design of laboratory research to yield data essential to scale-up requirements, compensation for field variables that normally do not influence lab performance, major scale-up precautions related to electrolytic process operating ranges; such as temperature, concentration, gas holdup, heat balance (emphasizing dynamic similitude), and the human factor.

In describing the operation of mercury cells, A. Basilevsky, of No. American Solvay stated that the design of the cells must be related to power consumption, space requirements, operating manpower, maintenance, and production capacity vs capital requirements. Adherence to these design criteria permits production to continue during cell adjustment and maintenance.

The critical relations of lag in automatic control systems and a review of the generally accepted methods for reducing lag to yield more effective control were described by J. G. Ziegler of Taylor Instrument, during the instrumentation portion of the program. In addition, he stated that many solutions for the problem of lag are related to the direct analysis and design of the system, rather than the shortcomings of the instruments. In the same part of the program, S. Spracklen of Beckman Instruments described process gas chromatography analysis, giving the historical background and specific applications. The instrumentation session was also bolstered by papers on Evaporator Controls; S. V. Kerstner of Foxboro, and Instrumentation of a Bauxite Reduction Plant: E. Ferce, Minneapolis-Honeywell.

The critical design and processing steps for corrosion resistant equipment manufacture were given by J. W. Koehler of Pfaudler in his description of fabrication of glass-lined steel equipment for the chemical industry. Experimental data on corrosion of glass and glass-lined steel and how concentration and temperature affect corrosion were presented by H. L. Otis, another Pfaudler representative at Twin-Cities (F. B. Richerson)

continued on page 158

#### NO MAJOR REPAIRS IN 25 YEARS\*

Sturtevant Construction Assures
Long Mill Life at Top Loads

Sturtevant crushing and grinding machinery answers the long life top-load production problem for medium to small size plants. Many Sturtevants have been operating above rated capacities for more than 25 years, and without a major repair.

"Open-Door" design gives instant accessibility where needed — makes cleanouts, inspection and maintenance fast and easy. Machines may be set up in units to operate at equal quality and capacity.



Jow Crushers — Produce coarse (5 in. largest model) to fine (1/6 in. smallest model). Eight models range from 2 x 6 in. jaw opening (lab model) to 12 x 26 in. Capacities to 30 tph. All except two smallest sizes operate on double cam principle — crush double per energy unit. Request Bulletin No. 062.



Retary Fine Crusher — Reduce soft to medium hard 3 to 8 in. material down to 14 to 144 in. sizes. Capacities up to 30 tph. Smallest model has 6 x 18 in. hopper opening: largest, 10 x 30 in. Non-clogging operation. Single handwheel regulates size, Request Bulletin No. 063.



Crushing Rolls — Reduce soft to hard 2 in, and smaller materials to from 12 to 20 mesh with minimum fines. Eight sizes, with rolls from 8 x 5 in, to 38 x 20 in.; rates to 87 tph. Three types — Balanced Rolls; Plain Balanced Rolls; Rolls and Balanced Rolls; Plain B



Hammer Mills — Reduce to 20 mesh. Swing-Sledge Mills crush or shred medium hard material up to 70 tph. Hinged-Hammer Pulverizers crush or shred softer material at rates up to 30 tph. Four Swing-Sledge Mills with feed openings from 6 x 5 in. to 20 x 30½ in. Four Hinged-Hammer Pulverizers with feed openings from 12 x 12 in. to 12½ x 24 in. Request Builtetin No. 084.

\*Reports Manager W. Carleton Merrill concerning Sturievant Swing-Sledge Mill at James F. Morse Co., Boston.

#### STURTEVANT

135 Clayton St., Boston 22, Mass-



Stacked in long rows on the shelves of a Dicalite laboratory, tagged and dated paper sacks like these are important to your processing. For they are an essential part of the extremely rigid quality-control system in every Dicalite plant...composite samples taken periodically during processing for the tests which insure Dicalite's unvarying dependability. These tests—more than 20,000 of them every month—may cover a wide range; weight or specific gravity, cake density, brightness, oil absorption, flowrate, particle size range and distribution, moisture content or other properties, depending upon the type of Dicalite product. No other mineral processed into powder form is so closely quality-controlled.

Laborious? Time-consuming? Certainly, but the only known way of producing, continuously, diatomaceous products which meet the Dicalite quality standards, admittedly the highest in the industry. And very often we are pleased to hear from customers, volunteering the information that their own independent tests confirm the fact that Dicalite products do conform to the highest standards... dependable, uniform, each lot just like all those before. This dependably uniform quality is the prime reason why many exacting firms have standardized on Dicalite filteraids or filler materials. We believe that your processing, too, will benefit with Dicalite. Investigate—write us today for information on how Dicalite can serve you.



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#### local sections

from page 156

one-day technical meeting in Minneapolis, February 20.

The theme of this symposium was What is a Chemical Engineer?, and his role in the fields of rockets, missiles, and other industries. Two dominant impressions left with those who attended were, "Do a better job than is asked for by your superiors, and in the event you move upstairs, don't forget that you were once, 'one of the boys'; that is, treat others as you would like to have been treated when you were being supervised." These cogent gems were left by R. F. Christensen who, incidentally, spoke ex tempo to fill an emergency gap in the program.

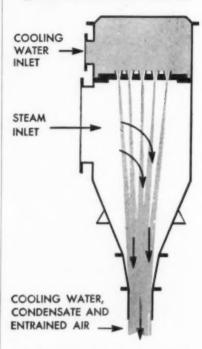
According to J. H. Kugler's definition, a chemical engineer must be a superman. In his Versatility of the Chemical Engineer Kugler elaborated the following: the chemical engineer is expected to know mechanical, electrical, and civil engineering; shop practices, labor management, economics, equipment costs, products made in chemical industry-by whom, why, and where, knowledge of raw materials and quality control, and read a considerable amount of technical journals, to name only a few things that were mentioned. In addition, since the chemist is limited in the type of training he gets, the physicist is not taught to solve chemical problems, and none of the other engineers know enough chemistry to solve processing problems, this role is left to the chemical engineer. Kugler did not stop here, but unfortunately

CEP's space is limited. Schools were challenged by M. H. Baker a Midwest Chemical Distributor to give engineers a broader base of business and economics before they get out into industry. The problem of accumulating and selling their ideas to top management, is one of the difficulties technical men face, according to E. B. Savage of Savage-Lewis, Inc. Management people do not often have time to carry on discussions, let alone read technical reports. Therefore he mentioned eight basic points which should always be conveyed in the technical report to management, to sell a project: be coherent, brief, single-minded, have the interest of the executive, use executive vernacular rather than engineering terms, be comparative, be graphic, be colorful. Above all, there should be a summary or conclusion, which briefly summarizes the results and offers practical suggestions for a solution to a problem. #

How to
CONDENSE STEAM
and
PULL A VACUUM

with nothing but

## WATER



#### I-R Ejector-Jet Barometric

Condensers provide low-cost condensation and evacuation wherever there is an ample supply of clean cooling water and the condensate need not be reclaimed. Since no air-removal equipment is needed, they are ideal for use where extreme simplicity of operation and low first cost are desired. Typical applications include steam turbine, vacuum pan and evaporator service.

In operation, water at atmospheric pressure or slightly higher enters at the top and is injected into the steam space through nozzles which form high-velocity jets. As the steam is condensed, air and gases are entrained by the water and carried to an open hot well. A valve in the water line is the only "control" needed.

Disc-flow type units are also available.

Send for Bulletin No. 9012-A



Published in the interest of better processing by Sprout, Waldron & Co., Inc., Muncy, Penna.

#### VERTICAL MIXERS **NEW SOURCE FOR** AGITATED STORAGE

Faced with the problem of maintaining batch uniformity, a prominent manufacturer found the solution in a battery of four 150 foot Vertical Mixers which serve as reservoirs.

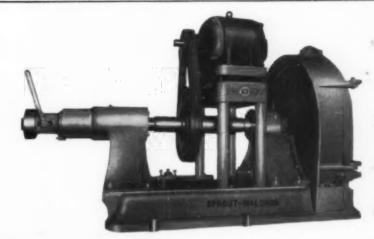
Stock emerging from the dryer is first passed through a disintegrating mill which breaks up any compacted lumps. The mill is fitted with properly vented surge hopper and a horizontal screw leading to each Vertical Mixer. In these mixers successive batches of die stuffs are thoroughly distributed among several preceding batches to assure continuous uniformity of the finished product.

For simplification, a single color is assigned to each mixer. This completely eliminates color contamination and frequent cleaning.

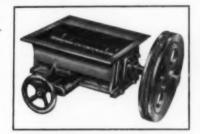
The Adaptioneered® Sprout-Waldron Vertical Mixers have to be dust-proof due to the fine character of the material. Each unit requires approximately 25 square feet of floor space and only 5 to 7 horsepower. The use of Vertical Mixers for agitated storage is a new twist, but a good one.



Self-loading Sprout-Waldron Bulk Trucks cut handling and delivery of dry materials in the process industry.



#### Adaptioneered®Attrition Mill Puts Spring in Cork



#### **BLOOD BOTTLES BUSTED**

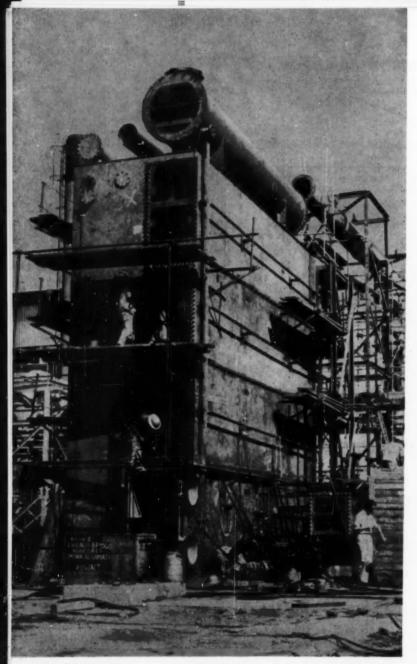
To avoid the risk of reusing unsterilized glass bottles used for the shipment of process blood, it was decided to destroy them by crushing in an Adaptioneered® Sprout-Waldron Single Roll Crusher.

Heavy duty glass bottles, the largest size being 31/" in diameter and 6" deep, are reduced to approximately "" ring size at the rate of 1,000 a day, by an 18" Single Roll Crusher requiring only 12" working head room and only 5 horsepower. Bulletin No. 116-A tells the up-to-date story on S-W Single Roll Crushers. Copies available on re-

To give cork the resiliency it needs to preserve the fizz in soda, the compression in your engine or the spring in your linoleum, it must be free of the hard pieces of bark that adhere so tenaciously. To remove this hard bark the granules were subjected to severe rubbing and squeezing on burr stone mills. Not only is this a slow process, with capacities approximately 750 pounds per hour, but dressing burr stones is a laborious and costly job requiring a special skill that is fast disappearing.

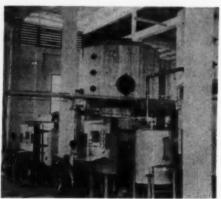
Adaptioneered® S-W Swinghead Single Disc Attrition Mills are now doing the job at twice the speed and for less money. In these mills the cork granules are rubbed and squeezed between two abrasive stone discs, one revolving and one stationary. The attrition mills are equipped with specially developed artificial stones available for a fractional cost of the original. Hand dressing is eliminated. Adaptioneering® saves this customer thousands of dollars annually in maintenance.

CP/102



Water from the Persian Gulf, the world's saltiest, is being purified by this four stage flash evaporator being installed by Westinghouse at Kuwait.

Two 50,000 gal./day flash type vapor compression evaporators at Salinas, Ecuador convert sea water into fresh water containing less than 0.25 grains of dissolved solids. Made by Cleaver-Brooks, they operate 24 hours a day with very little scaling.



## Saline water conversion . .

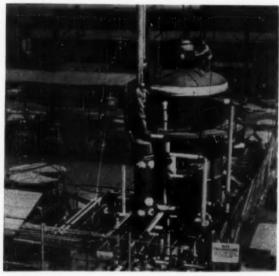
Fresh water is vital both for industrial and human consumption. With many areas of the world devoid of anything but saline water, and other areas rapidly increasing their water needs and not their basic supply, many companies are entering what may be a big business in the not too distant future. (In the U. S. alone, water needs will be doubled in from ten to fifteen years. Industrial areas of England have long been plagued with a water shortage which can only worsen.

Still in development, three facts stand out today in the salt water conversion field. 1) Conversion units are built in a wide range of sizes. 2) Methods used by the various companies to convert the water also vary widely. 3) Estimated costs of producing fresh water from salt vary just as much as the methods and unit sizes.

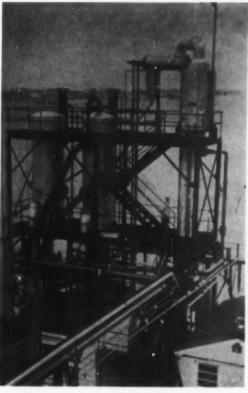
#### Production costs

Main reason for the wide range in cost estimates by the various companies is the diverse methods used to compute the costs. The immediate result of the differing methods is a confused and confusing set of estimated cost figures. In an attempt to have the different manufacturers come up with at least comparable cost figures, the Office of Saline Water has established standard methods for computing amortization, labor costs, maintenance costs, fuel costs, etc. Unfortunately, location and installation are such important factors that identical units give different cost data when installed in different locations. One important condition of installation is whether or not the unit is coupled to a waste, or byproduct, power source. Other important factors are site geography, the availability of cheap fuel of some sort, the possibility of tieing the unit to an existing power generating system.

## big business of future?



Also under test at Wrightsville Beach is the Hickmandesigned centrifugal compression still, manufactured by Badger Mfg. to produce 25,000 gal./day fresh water.



Distillation system designed by W. L. Badger & Associates, Inc. and manufactured by Swenson Evaporator Co., is at pilot plant stage at Wrightsville Beach, N. C.

#### Equipment and design

One basic problem in the design of the equipment is scale formation on heat transfer surfaces. Above about 170° F., scale precipitates on heating surfaces and reduces the transfer coefficient. A major effort of design, therefore, is to cause evaporation at reduced temperatures and avoid scaling.

Of the companies now in the field, the Maxim Silencer Co., Hartford, Conn., has recently installed units at the Castle Harbour Hotel, Bermuda, and at Caneel Bay, V. I. Both these resort areas have depended on catchment basin systems and imported water until now. The Maxim unit in Bermuda can produce 16,000 gal/day of fresh water containing less than 2

ppm dissolved impurities, and the unit at Caneel Bay can produce 27,000 gal/day of the same water.

The basis of the Maxim still is a combination multiple-effect, flash evaporator and thermal jet compressor. Since these units operate in the 200° F. range, scale forms and must be removed by a cold-shocking operation.

The Cleaver-Brooks Co., Waukesha, Wisc., is making a flash-evaporator type still which the company claims does not collect scale. Cleaver-Brooks units have been used on off-shore drilling rigs, Texas towers, and land locations in many countries.

Westinghouse Electric International is installing a 2% million gal/day system in Kuwait on the heavily-salt continued on next page



Maxim Silencer's double-effect flash and compression distillation unit now installed in Castle Harbour Hotel.



this

#### GOLDEN ANNIVERSARY

is your

#### GOLDEN OPPORTUNITY!

May 1958 CHEMICAL ENGINEERING PROGRESS will be a spectacular issue commemorating the "Chemical Engineers' Golden Jubilee"

The American Institute of Chemical Engineers' 50th Anniversary marks a major milestone in the progress of the Chemical Process Industries, from the celluloid era to today's rocket-fuel age. From vital discoveries in basic research, through the entire scope of chemical engineering, A.I.Ch.E. will celebrate fifty fabulous years of achievement.

A salute to the past is only part of the celebration. The main theme of the Jubilee program next June at Philadelphia will be "A Look to the Future." Here is the real significance of May CHEMICAL ENGINEERING PROGRESS for all advertisers—chemical engineers dedicated to the growth and development of all chemical industries.

This is truly a golden opportunity for manufacturers to instill both their corporate and their product messages in the minds of responsible chemical engineers — men whose decisions are essential to the purchase and specification of practically all chemicals, equipment, materials and engineering services in the chemical process industries.

Highlights of May C.E.P. include a History of Chemical Engineering and A.I.Ch.E., and a survey of Chemical Engineering Around the World, plus other fascinating features and timely engineering articles. This matchless editorial selection will insure intensive, effective readership.

Take full advantage of this unusual opportunity. The May 1958 issue of C.E.P. will be a big issue—your big opportunity to get big results. Be sure to reserve adequate space.



Published for chemical engineers by the American Institute of Chemical Engineers 25 West 45th Street, New York 36, N. Y.

#### Saline from page 161

Persian Gulf. Cost is no problem here since cheap fuel is available from the nearby oil fields. The unit at Kuwait has four evaporator stages, each evaporator consisting of two 35-foot towers with four stages mounted one above the other.

Under contract with OSW, the Swenson Evaporator Co. is conducting pilot plant studies in North Carolina for the multiple-effect distillation system proposed by W. L. Badger & Associates, Ann Arbor, Mich. Current work is aimed at reducing or eliminating scaling, but details are still under wraps.

Also being tested at the same North Carolina location is the Hickman designed single-stage centrifugal compression still built by Badger Mfg. Co., Cambridge, Mass. This unit operates under a 27-in. vacuum, and can convert 25,000 gal/day of 15 ppm pure water at 125-150° F. Basically, the unit is a series of hollow, rotating drums formed from facing pairs of copper and aluminum "pie plates." Sea water sprayed onto the interior surfaces spreads out into a thin film on each surface under the action of centrifugal force. Some of this water evaporates as low temperature steam, the rest is drained off as a concentrated brine. Operating below 150° F., this unit minimizes scaling.

Using experience gained from the larger unit, Hickman has also developed a smaller version for household and farm use which is capable of processing 400 to 500 gal./day. This unit is ten in. high by 30 in. diameter.

Another method, still on the drawing board, has been proposed by L. A. Bromley of the University of California. It is described as a multiple effect centrifugal evaporator. It appears to differ from the Hickman unit in that it would consist of a series of tiers mounted on a common vertical axis. Each tier would contain six stacks of 12 to 50 circular trays. The unit would produce 1- to 2-million gal./day; would operate on a countercurrent flow of sea water from above, and steam from below, to cause water to vaporize and condense on the undersurfaces of trays above and run into traps. Rotation of the trays would spread the water out into thin layers on the upper and lower tray surfaces. Salt would remain on each tray and be removed by other traps. Still experimental, it might take six years to develop this unit.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before May 15, 1958, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

#### MEMBER

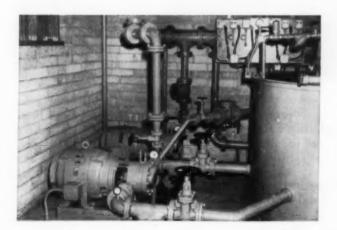
Adamson, N. A., Orange, Tex. Akell, Robert B., Wilmington, Del. Anhorn, Victor J., Akron, Ohio Bender, Rudolph A., Jr., Pittsford, N. Y. Benforado, David M., La Crosse, Wis. Blaine, Russell K., Peoria, Ill. Brown, Orval A., Baytown, Tex. Carter, Robert G., Wilbraham, Mass. Clark, John L., Blacksburg, Va. Culp, E. Harold, Memphis, Tenn. Dannerth, Frederic, Glenside, Pa. Dittman, Frank W., Pittsburgh, Pa. Estep, Emory Paul, Grand Island, N. Y. Findlay, Robert A., Bartlesville, Okla. Furman, Jacobo, Santiago, Chile Geankoplis, Christie J., Columbus, Ohio Geiger, James F., N. Linthicum, Md. Guillot, Edgar F., Stamford, Conn. Griffin, L. I., Baton Rouge, La. Hinterleiter, R. William, Seaford, Del. Holley, H. Q., Marshall, Tex. Jimeson, Robert M., Monongahela, Pa. Keppel, Reuben A., Gainesville, Fla. Kloiber, Fred G., White Plains, N. Y. La Pietra, Vincenzo, Milano, Italy Libey, Robert C., St. Paul, Minn. Maddox, Robert N., Stillwater, Okla. Matter, George B., Longview, Wash. McMurtrie, Robert, Midland, Mich. McRobbie, Henry W., Pittsburgh, Pa. O'Malley, Charles A., Allen Park, Mich. Parker, Robert O., New York, N. Y. Pearson, K. L., Independence, Mo. Pettengill, Kenneth H., Cincinnati, Ohio Rado, T. A., Syracuse, N. Y. Rao, Sanjeev A., Sr., Long Island, N. Y. Rice, James E., Richland, Wash. Robinson, George W., Baytown, Tex. Sapp, Junius E., Bogalusa, La. Seamster, Alfred H., Midland, Mich. Siegel, Louis, Pine Bluff, Ark. Sitman, William D., Malvern, Pa. Smirlock, Norton M., Philadelphia, Pa. Stadig, William P., Chestnut Hill, Mass. Steffler, Charles R., Lake Jackson, Tex. Taylor, William R., Cleveland, Ohio continued on page 168



A hippo surfaces with a cavernous yawn-powered by water from F-M pumps shown below.

#### From butterflies to hippopotami

F-M pumps make animals "live"



In one of the world's most fabulous amusement parks, waterfalls tumble; rivers flow; hippos yawn, and giant butterflies flap their wings—all water-powered by Fairbanks-Morse pumps with F-M motors.

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Raymond W. Hess, coordinator of pollution research for the National Aniline Division of Allied Chemical & Dye, receives a special award on behalf of the Manufacturing Chemists Association for his outstanding work in the field of water pollution. Making the award is L. W. Roznoy (right) of Celanese Corp. of America; at left is Gen. John E. Hull, USA (Ret.), MCA president. Occasion was a February 18 banquet in Washington, D. C.

Alex C. Burr, formerly consultant in fuels technology at the U.S. Bureau of Mines, has opened private consulting offices in Jamestown, North Dakota. Burr's practice will be largely confined to the investigation, development, and processing of the natural resources of the region.

Procter & Gamble announce two recent additions to their staff: E. Harry Brown joins the Development Department of the Soap Products Division; Robert R. Cooke will work in the Development Department of the Foods Division.

Lewis H. Conklin and James S. Benson have been named senior technical men at B. F. Goodrich Chemical's Development Center at Avon Lake, Ohio. Also at Goodrich Chemical, Richard G. Bauman becomes senior scientist, physical research de-

partment, at the company's Research Center, Brecksville, Ohio.

Alsop Engineering announces elec-



tion of Stanley R. O'Dette as director and vice-president of the corporation. O'Dette will also continue his activities as chief engineer, a position he has held since January, 1957.

General Tire & Rubber announces appointment of Robert S. Parkins as staff development engineer in its Chemical Division. Parkins, who joined General Tire & Rubber in 1954, was formerly a process engineer for General Electric.

J. Loshin has been appointed to the board of directors of Processes Research, Inc. of Cincinnati and New York. Loshin has been with the firm's Cincinnati office for the past seven years, prior to which he was a project engineer with Vulcan Copper and Supply Co.

J. C. Lawrence has been elected a director of the American Standards Association for a three-year term, start-

ing January 1, 1958.



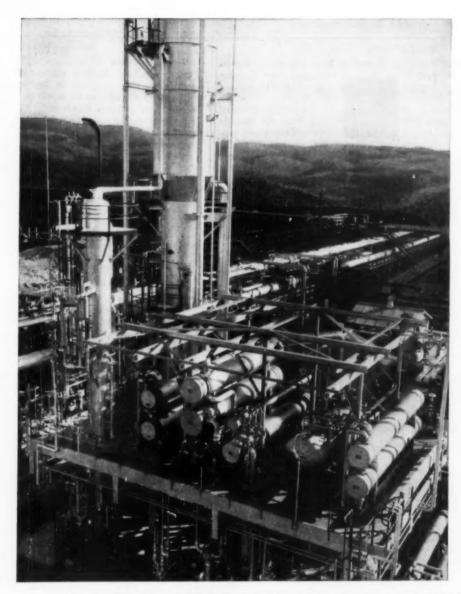
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CALIFORNIA STEEL PRODUCTS DIVISION, RICHMOND, CALIF.

YUBA HEAT TRANSFER DIVISION, HONESDALE, PA.

YUBA MANUFACTURING DIVISION, BENICIA, CALIF.



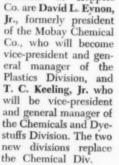
San Francisco Sales Office: 520 Balfour Building, New York Sales Office: 530 Fifth Avenue. from page 164

Joseph L. Gillman, Jr., Washington contributing editor of CEP and past chairman of the National Capital Section of A.I.Ch.E., has been appointed to serve an unexpired term of John T. Cox on the District of Columbia's Board of Registration for Professional

Newly-appointed group leader in Chemstrand's Research and Development Division is Charles H. Apperson. Prior to joining Chemstrand in 1952, Apperson was with the Tennessee Coal and Iron Division, U.S. Steel. In his present assignment, he will head the solution spinning group.

Named to head two newly-formed divisions at Koppers





Ernest P. Miller, of Cameron and Jones, consulting chemical engineers of Denver, Colo., arrived in Brazil February 21 to begin an 18-month assignment for Petroleo Brasileiro S/A, (Petrobras), the Brazilian National Oil Company. Miller's work in Brazil will be concerned with the Brazilian firm's petrochemicals development program.

Benzol Products Co., Newark, N.J.,



announce appointment of James B. Zimmerman as vice-president and general manager. For the past twenty-five years, Zimmerman has been plant manager of the company's Nixon, N.J., plant.



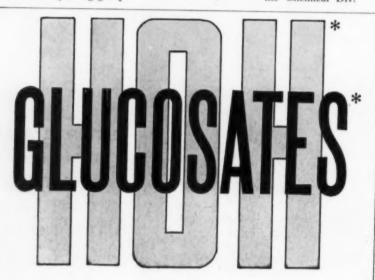
Walter L. Bass has joined Rust Engineering Co. as assistant to the vice-president, engineering. For the past three years, Bass has been in Paris, France, as a project manager for the Lummus Co., in which ca-

pacity he was responsible for the design and construction of a new oil refinery in Finland.

Gordon D. Kerns becomes senior technologist at the Potwin, Kansas, refinery of Vickers Petroleum. Kerns comes to Vickers from Amoco Chemicals Corp., where he held the post of manufacturing coordinator.

James Cooperman, research chemical engineer at Armour Research Founation of Illinois Institute of Technology, will head unit operations of the applied chemistry section at the Union of Burma Applied Research Institute in Rangoon. Cooperman has had previous international research experience in Mexico, where he directed development of laboratory processes for the Instituto Mexicano de Investigaciones Tecnologicas in Mexico City under an FOA contract with Armour Research Foundation.

I. O. Crockett has been elected president and chief executive officer of Goodrich-Gulf Chemicals, succeeding W. I. Burt, a past president of A.I.Ch.E., who becomes chairman of the board. Crockett, who has been vice-president, petro chemicals, Gulf Oil Co., will leave that company and undertake active direction of Goodrich-Gulf at its Cleveland headquarters. A veteran of nearly 36 years of service with Gulf, Crockett started with the company as a laboratory assistant at its Port Arthur, Texas, refinery.



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- Critical designs can be safely explored about the critical points.
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John P. Bainbridge, Jr., formerly with Monsanto Chemical, has joined Penick & Ford as assistant sales service manager. He will be headquartered in Cedar Rapids, Iowa.







Victor J. Carnell has been named Mid-West manager-sales engineer for Ever-Tite Coupling Co., New York. Carnell was formerly supervisor, operations department, Pennsylvania Division, Esso Standard Oil Co.

R. K. Hoddinott, Jr., appointed sales manager, sulfuric acid and phosphate rock for Davison Chemical Co. Also at Davison, David P. Barrett has been named sales manager, industrial chemicals.

U.S. Industrial Chemicals has named George C. Cook as manager of chemical market research and development. Cook was formerly associated with Allied Chemical & Dve and with the Lion Oil Division of Monsanto.

New assistant field sales manager of the Foxboro Co. is E. R. Huckman. He will aid in coordinating sales engineering activities of field personnel serving instrument users in the North and East. Huckman joined Foxboro

Robert L. Hart has been appointed district sales manager for Sinclair Chemicals. He will make his headquarters in Philadelphia.

George E. Davies, for the last four years sales engineer at Eastern Industries, Hamden, Conn., has been named New England district sales manager of the company's pump division.

#### Necrology

John B. Whitney, 76, retired. Whitney, an expert on design of sulfuric acid plants, had been associated with DuPont, National Lead, and Chemical Construction Corp.

Donald Kallman, 35, nuclear sales engineer, Babcock & Wilcox Co. Kallman was killed in an automobile accident near Rome, Italy.

Kenneth R. Brown, 61, vice-president (retired) of Atlas Powder Co., Wilmington, Del. Brown, who retired in 1956 as vice president and director of Atlas Powder, did pioneering work in the conversion of sugar to hexitols. Later, his work with sorbitol won him the 1955 honor awards of the Commercial Chemical Development Association.

#### A. I. Ch. E. Candidates

from page 162

Thayer, Victor R., Wilmington, Del. Thornberry, John, Permanente, Calif. Turner, Robert L., Newark, Del. Walters, Floyd G., Hatboro, Pa. Wessels, Delano E., Houston, Tex. Williams, Milt A., La Marque, Tex.

#### ASSOCIATE

Asti, Francis J., Aiken, S. C. Atwood, W. W., Metuchen, N. J. Bacon, Duane E., Brentwood, Mo. Bady, Daniel, Newark, Del. Baird, Robert M., Grand Island, N. Y. Baldwin, Maurice, Bronx, N. Y. Barrett, G. D., Kansas City, Mo. Benjaminson, Robert, Brooklyn, N. Y. continued on page 172



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- · No-pressure-drop construction of gate valve
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- Back-seating feature of cap: when valve completely open, relieves pressure on packing.
- Free-to-swivel plug: provides even wear of cap, perfect closure.
- Flexible synthetic cap: easily re-placed without removal of valve from line; minimal maintenance. Handles abrasive slurries without
- All-plastic design atyrene-copolymer. Replace-able caps available in Neoprene, Buna-N, and Hypalon (Kel-F elastomer on special order).

■ Suitable for vacuum — resilient cap makes excellent seal.

- PVC or Replace-Neoprene, on (Kel-F
  - Rated for 150-lb. service—PVC line up to 140°F., styrene-copolymer line to 170°F.

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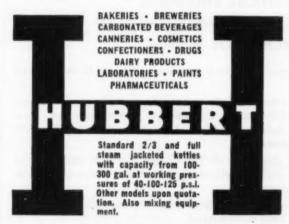
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III. (Northern) Wis. Webster Equipment Co. 549 W. Randolph Street Chicago, Illinois

S. C. Ga. Tenn N. C The Hoshall Company 1414 Morningside Drive Atlanta, Georgia

Mich Harry Holland & Son, Inc. 10600 Puritan Avenue Detroit 38, Michigan

Calif The Moore Drydock Co. Ft of Adeline Street Oakland, California

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Work consists of translating process requirements into completed operating pilot plants and includes mechanical design, proper application of equipment, instrumentation, cost estimation, scheduling, materials procurement, field supervision of construction, initial operating shake-down, and new equipment development.

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- CHEMICAL ENGINEER—M.S., Registered Engineer, veteran, age 41. Six years' process design and economic evaluations, petroleum and petro-chem. Also eight years' diversified chemical engineering experience. Desire position involving engineering sales consulting and/or teaching. Box 5-4.
- CHEMICAL ENGINEER—Tau Beta Pi. Fourteen years diversified industrial experience in petrochemicals, petroleum refining, ammonia. Emphasis on commercial development corporate diversification, acquisition. Substantial background in economics and process design. Assignments include project engineer, Assistant to Vice President, etc. See\*Ling responsible assignment with opportunity. Box 6-4.
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- CHEMICAL ENGINEER B.Ch.E. Pourteen years' diversified experience in process development, economics, and sales. Desire administrative work in small to medium progressive eastern company. Will consider offers over \$9,000. Resume available. Family. Box 10-4.
- ADMINISTRATION—M.I.T., B.Ch.E. 1954. Wharton M.B.A. expected 1958. Age 26. Veteran. Desire position in project, production or research planning and administration. Available July 1st. Minimum salary \$6.500. Box 11-6.

(continued on page 172)

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in C. P. I.? See Page 34

#### A. I. Ch. E. candidates

from page 168

Berens, Norman, Bronx, N. Y. Berg, Gilbert G., Baton Rouge, La. Bonem, Joe M., Baytown, Tex. Booker, Robert J., San Francisco, Calif. Boss, A. E., Jr., Elizabeth, N. J. Bossler, Thomas H., Pitcairn, Pa. Bray, Bruce G., Ponca City, Okla. Brigham, Ewell A., La Porte, Tex. Bugos, Ronald G., Munhall, Pa. Calsing, Harry R., Wadsworth, Ohio Capik, Robert J., Newark, N. J. Cataneo, Ferdinand C., Brooklyn, N. Y. Chalishazar, B. H., Bombay State, India Chase, Joseph D., Corpus Christi, Tex. Clark, George C., Ponca City, Okla. Clarke, T. A., Crystal Lake, Ill. Craft, William S., Grand Junction, Colo. Cytron, Sheldon J., Brooklyn, N. Y. Darnell, W. Thomas, Wilmington, Del. Davis, Harris, Bronx, N. Y. Dobrohotoff, Vladislav V., New York,

Eckert, Richard A., Brooklyn, N. Y. Eidt, Clarence M., Jr., Baton Rouge, La. Elder, Harry J., Springdale, Pa. Fein, Elliott D., New York, N. Y. Gasior, Stanley J., Pittsburgh, Pa. George, Charles R., Euclid, Ohio Graham, Tommy E., Texas City, Tex. Griscavage, Albert John, Harmarville, Pa. Hansen, Fred W., Jr., Baytown, Tex. Heath, Harry W., Jr., Charleston, W. Va. Heck, Stephen B., Jr., Texas City, Tex. Henry, Shirley E., Montrose, Ark. Hixon, Philip E., Westbury, N. Y. Honor, Robert S., Bronx, N. Y. Hrinkevich, Nicholas, New York, N. Y. Johnson, Benjamin L., Jr., Hammond, Ind.

Johnson, L. M., Baytown, Tex.
Johnson, Ronald L., Midland, Mich.
Johnstone, Arthur L., Lake Jackson, Tex.
Katz, Saul, Brooklyn, N. Y.
Kaufman, David, Bronx, N. Y.
Kelly, John J., Jr., Niagara Falls, N. Y.
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#### news and notes of A.I.Ch.E.

Northern California Section of A.I.Ch.E. issued last year a miniature, 3%- by 4%-inch, directory of its members, which is remarkably complete & a good idea for other sections. . . . The reproduction process used, photooffset printing from typewritten copy, is probably not too expensive a job to turn out & yet is extremely practical. The Northern California directory lists officers; by-laws; members' addresses, companies, & status; & particularly interesting to me as Secretary, the record of growth of the section from 1945, when there were 100 paid members, to June, 1957, when there were 433. Also included is information on the University of California (Berkeley) & Stanford University Student Chapters & a description of the Northern California Student Chapter Award. The Secretary of the Northern California Section, G. H. Goff, California Research Corp., Box 1627, Richmond 1, Calif., will, I am sure, be glad to supply copies to Local Sections interested.

Mason-Dixon-Jones Line-Matt Jones has divided the nation into the North & the South again by extending the Mason-Dixon Line to the West Coast. . . . Victory on this occasion will go to the area supplying the greater number of new members. (Matt's nonpartisan.) He thus hopes to exceed in 1958 the figure of 1,185 new members brought in in 1957 while Johnny McKetta was Membership Chairman. The first results of the contest between the North & the South are in & for the month of January the North, under Sam West, Philadelphia-Wilmington Section, leads by eleven members. The thirty-one sections under his leadership turned in fifty-two new members; whereas the South, under Irv Leibson, South Texas, turned in forty-one. But Sam is not resting on his laurels because, as he pointed out in a special memo to all the Membership Committeemen under his leadership, the January, 1958, results were fifteen fewer than those for 1957, & this entire drop was in the northern division. Sam's idea, to organize his division on a grass roots basis, will make this an interesting year.

The practice of consulting engineering—C. W. Nof-singer, Chairman of the A.I.Ch.E. Ad-hoc Committee on Consulting Practice, reported to the February meeting of Council on a special manual for consulting engineers, issued by E.J.C. . . . Chuck's alternate to the E.J.C. committee on consulting practices was James H. Boyd. The handbook, which is designed to help clients as well as consulting engineers in the use of professional engineering services, was accepted by Council in principle as a guide for consulting engineers. Anyone interested in securing a copy of the manual may obtain one from headquarters at a cost of \$1.50.

Council liaison to committees—One of the important contributors to functioning & to rapport among members,

committees, & Council is the liaison member. . . . For guidance, here are the liaison members of Council appointed in February & the committees that they coordinate: Admissions, D. F. Othmer; Awards, E. R. Gilliland; Career Guidance, J. J. Healy; Chemical Engineering Education Projects, J. H. Koffolt; Constitution & By-laws, H. F. Nolting: Education and Accreditation, J. H. Rushton; Equipment Testing Procedures, W. R. Marshall; Fiftieth Anniversary, G. E. Holbrook; Membership, J. J. McKetta; Pollution Control Engineering, J. H. Koffolt; Professional Development, Jerry McAfee; Professional Legislation, J. J. Healy; Program, R. H. Wilhelm; Publications, H. F. Nolting; Public Relations, Jerry McAfee; Research, Manson Benedict; Sections Activities, D. L. Katz; Standards, W. R. Marshall; Student Chapters, C. A. Stokes; Symbols & Nomenclature, Manson Benedict. Should any member have a problem in any of these areas, he should write directly to the Council liaison member (addresses in the A.I.Ch.E. Directory, obtainable on request). Several areas of activity are not represented by formal committees, but are the special interest of particular Council members: as an example, D. L. Katz was appointed liaison in charge of divisions; Ray Genereaux, who is working on fund raising for the United Engineering Trustees, was asked also to be Council's representative to this area; President George Holbrook is interested in engineering unity & the Nuclear Congresses. Each Local Section too has a liaison member of Council. Sections have been notified of their liaison member; however, any Local Section officer who wants a list of these representatives needs just to drop a note to headquarters.

Raising \$300,000 from the membership of A.I.Ch.E. for the United Engineering Center is the task of W. G. Whitman & S. D. Kirkpatrick. . . . The kick-off was made at the recent Council meeting & plans are now underway for the organization of the Member Giving Campaign in the New York area, to be followed by a campaign in Local Sections throughout the country, the idea being to organize a committee of fifty men to assist.

Opportunities for service to A.I.Ch.E. exist in many forms, outside the regular committees. . . . We very often have representatives to various programs; for instance, W. J. Alford of Chicago is our official representative to The Twentieth Annual meeting of the American Power Conference; H. W. Field & R. A. Matteson are delegates to the Sixty-second Annual Meeting of the American Academy of Political and Social Science in Philadelphia; W. E. Lobo represents us on the U. S. National Committee of the World Power Conference; N. A. Shepard & S. L. Tyler are delegates to the National Social Welfare Assembly. F.J.V.A.



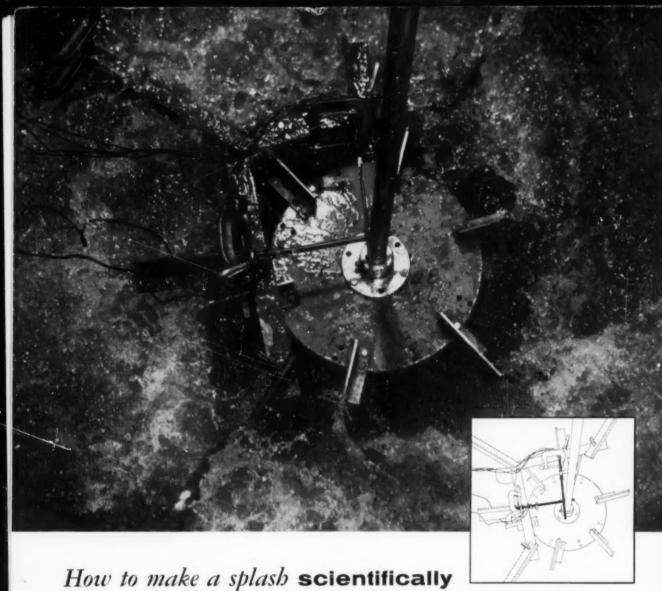


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